TOPOGRAPHY AND GEOLOGY OF THE RIUKIU ISLANDS

TOPOGRAPHY AND GEOLOGY OF THE RIUKIU[1] ISLANDS

BY

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(With 15 Plates, 7 Text-figures, 1 Chart, and 5 Geological Maps)

Introduction

These notes, which cover a part of the results of my recent studies on the geology of the Riukiu Islands, serve also as Explanatory Texts to the accompanying five Geological Maps of these Islands.

My first visit to the islands was in 1924, when about 40 days during the months of March and April were spent on Okinawa-jima.[2] Since then, in 1929 and 1930, with the financial support of the Imperial Academy, I made two trips to Taiwan (Formosa)[3] and continued my investigations in connection with Professor H. YABE's stratigraphical study of the geology of this island. In 1931, about 70 days during the months of May and July were spent in the Yaeyama[4] group, followed in 1932 by another stay of 82 days, between the months of May and July, in the Okinawa and Ôshima[5] groups. The last two trips were financed by the SAITÔ Gratitude Foundation.

Before proceeding farther, I wish to express my gratitude to the council of the Imperial Academy (Tôkyô) and the SAITÔ Gratitude Foundation (Sendai) for their generous support in the form of grants to enable the prosecution of these studies. My cordial thanks are due to Professor H. YABE for his kind advices and critisisms on the whole subject and for his laborious undertaking of reading the manuscripts; to Messrs. R. AOKI and F. UEDA for their assistance in matters pertaining to the geomorphology and stratigraphy of these islands, and to M. YOSSII for the same in petrography. Finally, it is my pleasant duty to acknowledge my indebtedness to the following gentlemen, who in their capacities, official and otherwise, extended me every courtesy and rendered valuable assistance during my stay in the islands; namely, Mr. T. IWASAKI, former Chief of the Meteorological Station at Ishigaki-jima,[6] Mr. T. ISHII, Chief of the Meteorological Station at Amami-ô-shima, Messrs. CHÔSA, KOKUSHÔ, HAYASHI, and HIGUCHI, officials of the Forestry Office of Okinawa Prefecture; Mr. C. MADANBASHI, Principal of the Shirara Primary School, Ishigaki-jima; Mr. C. KAPIRA, Principal of the Asato Girl's School, Naha City, Okinawa-jima, and Mr. K. IESAKA, Health Officer, Okinawa Prefecture.

Nomenclature of the Riukiu Islands

Dr. B. KOTÔ, (Lit. 5) Professor Emeritus, Tokyo Imperial University, was the first to apply the name "Riukiu Curve" to the festoon of islands that stretch from the southern end of Kyûshû[7] to the northeast of Taiwan (Formosa). Since then, the names "Riukiu Curve" and "Riukiu Islands", found general acceptance among writers on geography and the related sciences. Occasionally they are referred to as "Nansei shotô",[8] (southwestern islands), the name used on charts issued by the Imperial Hydrographical Department.

1) 琉球, 2) 沖繩島, 3) 臺灣, 4) 八重山群島, 5) 大島, 6) 石垣, 7) 九州, 8) 南西諸島

The Riukiu Curve, or Riukiu Islands, comprises the following islands, enumerated from the north: (**a**) Tane-ga-shima,[1] Mage[2]-jima, Yaku[3]-shima,[4] (**b**) Take,[5] Kuro,[6] Iwô,[7] Kuchinoerabu,[8] Kuchi (Kuchi-no-shima),[9] Naka (Naka-no-shima),[10] Suwanose,[11] Gaja,[12] Kogaja,[13] Tera,[14] Akuseki,[15] Takara,[16] Kotakara,[17] Kaminone,[18] Yokoate,[19] (**c**) Amami (Amami-ô-shima),[20] Edato (Edeku),[21] Kakeroma,[22] Uke,[23] Yoro,[24] Sukomo-banare,[25] Kikai[26] (Kikai-jima or Kikai-ga-shima), Toku[27] (Toku-no-shima), Okierabu,[28] Yoron,[29] Tori,[30] (**d**) Okinawa, Ie,[31] Kouri,[32] Sesoko,[33] Minna,[34] Wô,[35] Yagaji,[36] Yabuji,[37] Henza (Henza-banare)[38] Taka[39] (Taka- or Miyagusuku[40]-banare), Ike[41] (Ike- or Ichi-banare), Hamahiga[42] (Hamahiga-banare), Ukibaru,[43] Minami-(or Fê-) ukibaru,[44] Tsuken,[45] Kudaka,[46] Senaga[47] (**e**) Iheya (Iheya-shiri-jima),[48] Noho,[49] Gushigawa,[50] (Gushichâ), Izena[51] (Iheya-mae-jima),[52] Yanoshita,[53] Yanaha,[54] (**f**) Aguni,[55] (**g**) Kume,[56] Wô, Ôha,,[57] Tori, (**h**) Tonaki,[58] (**i**) Kê-sansho[59] (Kê, Minna, and Kamesu),[60] (**j**) Mae,[61] Naka,[62] Hate,[63] Kuro,[64] Tokashiki,[65] Gusuku,[66] Fukase,[67] Jifushi[68] (Gifushi), Zamami,[69] Amuro,[70] Akenashiki,[71] Kahi,[72] Aka,[73] Geruma,[74] Fukashi[75] (Hokaji), Wô, Yukan,[76] Kuba,[77] (**k**) Miyako,[78] Ikema,[79] Kûma, (Kurema),[80] Irabu,[81] Shimoji[82] Minna,[83] Tarama,[84] (**l**) Ishigaki,[85] Iriomote,[86] Kobama,[87] Taketomi,[88] Kayama,[89] Kuro,[90] Aragusuku[91] (-kanji[92] and -shimoji),[93] Hateruma,[94] Hatoma,[95] Nakanogan,[96] Yonaguni[97] (Yonakuni), and (**m**) Kita-ôagari,[98] Minami-ôagari,[99] and Oki-ôagari.[100] Besides these, the Pinnacle group, comprising Sekibitô[101] (Raleigh reef), Kôbitô[102] (Tai-a-usu) and Chôgyotô[103] (Hoa-pin-su) and the Agincourt[104] group, comprising Agincourt, Menkwatô[105] (Craig), and Kwaheitô[106] (Pinnacle), all lie northeast of Kiirun[107] (Keelung), Taiwan.

These islands, which form a number of groups, vary much in size as well in the distances that separate them. Dr. S. Tokunaga (Lit. 12) grouped the islands just enumerated in (**a**) into the Ôsumi group; those in (**b**) into the Tokara[108] (Linshoten) group; those in (**c**) into the Ôshima[109] group; all those in (**d**), (**e**), (**f**), (**g**), (**h**), (**i**), and (**j**), into the Okinawa group; those in (**k**) and (**l**) into the Miyako and Yaeyama[110] groups, respectively. He further subdivided the Okinawa group into the Okinawa subgroup, consisting of the islands in (**d**), the Iheya subgroup comprising those in (**e**), and the Kerama[111] subgroup those in (**j**).

F. v. Richthofen (Lit. 14, p. 949) on the other hand, combined the Ôshima and Okinawa groups into the Ôshima-Okinawa group, and the Miyako and Yaeyama groups into the Sakishima[112] group.

E. M. H. Simon (Lit. 20, p. 1) used the term "Riukiu Islands" in a much narrower sense, restricting its use to those islands lying between Lat. 24°06′ N.—28°35′ N., that is to say, to the Ôshima-Okinawa, Miyako, and Yaeyama groups, excluding from it however the Ôsumi group.

Politically, the Ôsumi group forms Kumage-gun, Kagoshima Prefecture; the Tokara and Ôshima groups (excluding Tori, lying west of Toku), forms Ôshima-gun in the same prefecture. The rest belong to Okinawa Prefecture, of which the northern division of Okinawa-jima, together with

1) 種子ヶ島, 2) 馬毛, 3) 屋久.

4) The Japanese terms "shima" or "jima", and "hanare" or "banare", mean an island or islands. For brevity, these terminations are omitted in this paper.

5) 竹, 6) 黒, 7) 硫黄, 8) 口之永良部, 9) 口之島, 10) 中之島, 11) 諏訪之瀬, 12) 臥蛇, 13) 小臥蛇, 14) 平, 15) 悪石 16) 寶, 17) 小寶, 18) 神之根, 19) 横當, 20) 奄美大島, 21) 枝手久, 22) 加計呂麻, 23) 請, 24) 與路, 25) 須子茂離, 26) 喜界, 27) 德之島, 28) 沖永良部, 29) 與論, 30) 鳥, 31) 伊江, 32) 古宇利, 33) 瀬底, 34) 水無, 35) 奥武, 36) 屋我地, 37) 藪地, 38) 平安座, 39) 高, 40) 宮城, 41) 伊計, 42) 濱比嘉, 43) 浮原, 44) 南浮原, 45) 津堅, 46) 久高, 47) 瀬長, 48) 伊平屋後島, 49) 野甫, 50) 具志川, 51) 伊是名, 52) 伊平屋前島, 53) 家ノ下, 54) 屋那覇, 55) 粟國, 56) 久米, 57) 奥端, 58) 渡名喜, 59) 慶江三嶼, 60) 龜洲, 61) 前, 62) 仲, 63) 端, 64) 黒, 65) 渡嘉敷, 66) 城, 67) 深瀬, 68) 儀布志, 69) 座間味, 70) 安室, 71) 安慶名敷, 72) 嘉比, 73) 阿嘉, 74) 慶留間, 75) 外地, 76) 屋嘉比, 77) 久(古)場, 78) 宮古, 79) 池間 80) 來間, 81) 伊良部, 82) 下地, 83) 水納, 84) 多良間, 85) 石垣, 86) 西表, 87) 小濱, 88) 竹富, 89) 嘉彌眞, 90) 黒, 91) 新城, 92) 上地, 93) 下地, 94) 波照間, 95) 鳩間, 96) 仲之神, 97) 與那國, 98) 北大東, 99) 南, 100) 沖, 101) 赤尾島, 102) 黄尾島, 103) 釣魚島, 104) 彭花島, 105) 綿花島, 106) 花瓶島, 107) 基隆, 108) 土噶喇, 109) 大島, 110) 八重山, 111) 慶良間, 112) 先島.

the islets of Ie, Sesoko, Kouri, Minna, Yagaji, and Wô belong to Kunigami-gun, whereas the middle division of Okinawa-jima, together with the islets of Kudaka, Tsuken, Ukibaru, Minami(Fè)-ukibaru, Hamahiga, Henza, Taka, Ike, and Yabuji to Nakagami-gun ; the southern division of Okinawa-jima, the Iheya and Kerama subgroups, Aguni, Tonaki, Kume, Ôha, Wô, the Kê sansho, Tori (already mentioned and a small islet of the same name lying north of Kume), to Shimajiri-gun ; the Miyako group to Miyako-gun ; and the Yaeyama group to Yaeyama-gun. Okinawa Prefecture has, in addition the three Ôagari islands, lying in a north and south line about 320 km. east of Okinawa ; these three islands geographically speaking, constitute an independent island line.

Previous Work on the Riukiu Islands

The earliest scientific papers on the Riukiu Islands are those by R. G. JONES and L. DÖDERLEIN. The former, according to F. v. RICHTHOFEN. (Lit. 14, pp. 947, 948), reported in 1850 the occurrences of gneiss, shale with doubtful coal seams, and fossiliferous limestones in the north of the city of Naha[1] in Okinawa, while the latter in 1880, according to E. SUESS (Lit. 2, p. 219), first called his attention to an important feature of the Riukiu Islands whereby they are arranged into two rows, those in the inner row, the Tokara (Linshoten), Tori, Aguni, and Kume, all being volcanic and those in the outer row, Tane, Yaku, Amami, Kikai, Toku, Yoron, and Okinawa being non-volcanic. On the strength of this information, E. SUESS (Lit. 2, p. 219) inferred that the Riukiu Islands represent one of a number of ancient folded mountain systems and pointed out that the island group is comparable in structure with those of the Antilles, the Nikobars, the Andamans, the Appenines, and the Carpathians, in each of which foreign examples a non-volcanic zone is always accompanied on the inner side by a volcanic zone.

According to Mr. KUROIWA (Lit. 3), who in 1893 described the geology of Okinawa, the northern half of it consists of pre-Cambrian and the southern half of Cenozoic rocks.

In 1895, Mr. NISHIWADA (Lit. 4) described Tane, which is composed of folded Tertiary strata, covered with gravel beds in several places ; also Yaku, which consists mainly of granite, surrounded by a narrow strip of slates, sandstones, conglomerates, and hornfelses.

The most important contribution to the geological structure of the Riukiu Islands was made by Dr. B. KOTÔ (Lit. 5) in 1898, after exhaustive study of a geological map of Okinawa prepared by Mr. KADA and that of a note on the geology of the Yaeyama group by Mr. NAKAYOSHI, besides the reports of KUROIWA and NISHIWADA just mentioned. The Riukiu Islands, being at that time virtually *terra incognita*, geologically speaking, I cannot but admire his well founded interpretations on their geological structure, based on material so scanty, and which, in its essentials, have stood the test of time so well, affected but little by the results of subsequent investigations. His views in short are as follows :

In structure, the Riukiu Curve is divisible into three longitudinal zones, the inner, middle, and outer. The middle zone, which comprises the larger islands, Yaku, Amami, Toku, Yoron, the northern division of Okinawa, Kouri, Ie, Sesoko, Yagaji, the Iheya subgroup, the Kerama subgroup, Ishigaki, Iriomote, etc., is composed of Proterozoic or Palaeozoic rocks and igneous rocks. The outer zone, which includes Tane, Mage, Kikai, the southern and middle divisions of Okinawa and its dependent islets lying on the east of the island, all the islands of the Miyako group, and some of the Yaeyama group (Yonaguni and Hateruma), etc., consists of Tertiary and younger rocks. The inner zone, which comprises all the islands of the Tokara group, Tori, Aguni, Kume, and the Agincourt-Pinnacle group is volcanic. This volcanic zone with Kaimon-dake,[2] On-take[3] (in Sakura-jima),[4]

1) 那覇, 2) 開聞嶽, 3) 御嶽, 4) 櫻島.

Kirishima-yama,[1] and Aso-zan[2] on its northern prolongation, was believed to continue to the Daiton-zan,[3] an almost unique volcano situated at the northernmost point of Taiwan (Formosa) in its southern prolongation. The middle zone is a remnant of the Riukiu Cordillera, which came into existence during the Palaeozoic Era, its higher parts alone being now visible above the sea. The great gap in the middle zone between Okinawa and Ishigaki and another one in the volcanic inner zone in the corresponding region suggest the existence of a great rift or fault traversing the cordillera.

KUROIWA (Lit. 6), who later visited Kume and Aguni, confirmed the prevalent belief that the two islands consist mainly of younger volcanics.

One of the most valuable contributions to the geology of the Islands is that of Dr. S. TOKUNAGA (Lit. 7, 11, 12), who, in the course of his geological reconnaissance in 1900, visited most all the islands with the exception of the Ôsumi and Tokara groups. The results of his field and laboratory studies were published the following year, the report containing much new information that helped to advance our geological knowledge. The oldest formation, hitherto believed to be either pre-Palaeozoic or Palaeozoic, is now definitely assigned by him to the Palaeozoic. The coal-bearing Tertiary formation of the Yaeyama group was correlated with that of the northern part of Taiwan, which YABE and HANZAWA (Lit. 39, p. 8) now call the Kaizan beds. He also found "raised coral reefs" extensively developed on many of the islands, and assigned the Pleistocene age to the limestone formation, which YABE and HANZAWA (Lit. 39, p. 9) now call the Riukiu limestone to distinguish it from the geologically much younger, true raised coral reefs.

With the works of KOTÔ (Lit. 5) and TOKUNAGA (Lit. 7, 11, 12) on the geology of the Riukiu Islands and Taiwan and that of N. YAMASAKI (Lit. 10) on the geography of the latter island, as basis, F. v. RICHTHOFEN (Lit. 14) in 1902 successfully incorporated the Riukiu Islands into his grand plan—the Geomorphology of Eastern Asia. He accepted the three longitudinal zones distinguished by KOTÔ and TOKUNAGA, recognizing therein a simple and typical island arc convex to the Pacific, which came into existence as the result of a crustal disturbance forced from the inner side to the outer. He further traced the inner volcanic zone as far as Volcano Aso in the northern part of Kyûshû and gave an elaborate explanation of the connection of the island arc to Kyûshû on the north and to Taiwan on the south.

Meanwhile NEWTON and HOLLAND (Lit. 13) recorded the discovery of *Lepidocyclina* in a limestone from Sonai, Iriomote, in TOKUNAGA's collection, and established for the first time the occurrence of a Miocene fossiliferous rock in the islands.

Later, H. YABE (Lit. 21) found *Pellatispira* in several limestones from Ishigaki, in TOKUNAGA's collection, and recorded the occurrence of an Eocene rock in the Yaeyama group.

In 1925, H. YABE and HANZAWA (Lits. 22, 26, 28, 29) described a number of foraminifera from the Riukiu limestone of Okinawa, Miyako, Toku, and Taiwan and also the Shimajiri beds of Okinawa (underlying the Riukiu limestone), all from the collections of Messrs. TOKUNAGA, C. IWASAKI, U. DEGUCHI, Y. OINOUYE and C. KAPIRA. The limestone formation, "the Raised Coral Reefs" of TOKUNAGA, was then thought by us to be youngest Pliocene rather than Pleistocene in age.

It might be added that a number of papers on the topography, geology, and palaeontology of these islands, written by members of our Institute of Geology and Palaeontology, have been published.[4] These are based mostly on material collected by me and also by R. AOKI. In

1) 霧島山, 2) 阿蘇山 3) 大屯山.

4) The list of recent publications on the topography, geology, and palaeontology of the Riukiu Islands issued by the members of our Institute of Geology and Palaeontology : is as follows ;

H. YABE and T. SUGIYAMA : Reef-Building Coral Fauna of Japan. *Proc. Imp. Acad.* Vol. VII, No. 9, 1931, pp. 357–360.
H. YABE : Colonial Corals in the Geological Formations of the Japanese Islands, *Ibid.* Vol. VIII, No. 7, 1932, pp. 304–307.

January, 1931, R. Aoki visited the Miyako and the Yaeyama group. I am greatly indebted to him for information concerning the morphology of the islands.

Submarine Topography around the Riukiu Islands.

General Features.

(See Imp. Japan. Nav. Chart, No. 210).

The Riukiu Islands are arranged between Taiwan and Kyûshû in an arc, convex southeastwards, with the 7,000 m.[1] foredeep, the Riukiu trench, along its convex side. Lying east of this deep are three limestone islands, Kita-, Minami-, and Oki-ôagari (-daitô), on a deep submarine ridge in a N.—S. trend and situated 328 km. east of Okinawa-jima. The Tung-hai (Higashishinakai),[2] the epicontinental sea enclosed between the Riukiu Islands and the Asiatic continent has a wide continental shelf, which rim marked by the 200 meter submarine contour-line that almost coincides with an imaginary line drawn from Kiirun (Keelung)[3] in Taiwan to Kagoshima[4] in Kyûshû. An elongated deeply depressed basin, lying between the continental shelf and the main zone composed of sedimentary rocks, of the Riukiu Islands, has depths ranging from over 2,000 m. along the Sakishima group to 1,000 m. along the Okinawa-Ôshima group. Volcanic islands of the inner zone rise sheer from the bottom of this deep.

The Ôsumi Group (See Imp. Japan. Nav. Charts, Nos. 182a and 1222).

All the islands of the Ôsumi group, Tane, Mage, and Yaku, lie on one and the same insular shelf as Kyûshû. Tane is a long island in a N. N. E.—S. S. W. direction, with its east and west coasts linear and parallel to the longer axis of the island. The shelf on both the east and west sides of the island is 22 km. wide and is limited seawards by the 200 m. submarine contour. The outer rim of the shelf on the east side, which runs parallel with the longer axis of the island, slopes downward, dropping abruptly to the sea bottom, which has a depth of 1,000 m. or more, while that on the west side descends very gradually into the deep sea bottom with no abrupt change in slope.

Take and Iwô, two volcanic islands west of Tane, are separated from the shelf, carrying the Ôsumi group, by a water 400 m. or less deep.

Tane is separated from Mage and Yaku by seas of 60 m. and 50 m. maximum depth, respectively. The west coast of Yaku, which is of cliff-type, descends steeply to a depth of over 4,000 m. The front of the south coast shelf is not clearly defined, but the sea-bottom there slopes

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H. Yabe and M. Eguchi : Deep-Water Corals from the Riukiu Limestone of Kikai-jima, Riukiu Islands, *Ibid.* Vol. VIII, No. 9, 1932, pp. 442–445 with a Text fig. H. Yabe and T. Sugiyama : Subfossil Gizzard Stones Probably of Birds Found in the Phosphate Deposit of Kita-Daitô-zima, *Ibid.* Vol. X, No. 6, 1934, pp. 361–364, Text-figs. a–m. H. Yabe and T. Sugiyama : Notes on Three New Corals from Japan, *Japan. Jour. Geogr. & Geol.* Vol. XI, Nos. 1–2, 1933, pp. 11–18, pl. I–IV. H. Yabe : Brachiopods of the Genus *Pictothyris* Thomson, 1927, *Sci. Rep. Tôhoku Imp. Univ. 2nd Ser. (Geol.)*, Vol. XV, No. 3, 1932, pp. 193–197, pl. XIII. H. Yabe and T. Sugiyama : Reef Corals Found in the Japanese Seas, *Ibid.* Vol. XV, No. 2, 1932, pp. 143–168 with 6 Text-Figs. and 1 Table. S. Nomura and N. Zinbô : Marine Mollusca from the "Ryûkyû Limestone" of Kikai-zima, Ryûkyû Group, *Ibid.* Vol. XVI, No. 2, 1934, pp. 109–164, pl. V. S. Nomura and N. Zinbô : Marine Mollusca from the Simaziri Group of Okinawa-zima, Ryûkyû Group. (now in preparation). S. Hanzawa : On a *Neoschwagerina*-Limestone from Okinawa-jima, Riukiu (Loo-choo) Islands, *Japan. Jour. Geol. & Geogr.* Vol. X, Nos. 3–4, 1933, pp. 109–110, pl. VII. S. Hanzawa : An Outline of the Geology and Geologic History of the Yaeyama Subgroup (in Japanese), *Geographical Review of Japan,* Vol. VIII, No. 2, pp. 119–130, pl. I–III, 1932. R. Aoki : On the Geology and Topography of Miyako and Isigaki-zima, Ryûkyû Curve, *Trans. Japan. Assoc. Advanc. Sci.* Vol. VII, No. 3, 1932, p. 333.

1) It is to be understood that all measurements given in this paper in round number, e. g., 250, 200, etc., such for example, as depths of seas ; heights of mountains, terraces ; thicknesses of beds ; widths of terraces, streams ; distances between points, etc., unless stated to the contrary, are only approximate.

2) 東支那海, 3) 基隆, 4) 鹿兒島.

gently down to as much as 500 m. without any scarps. South of Yaku is a broad flat-topped and steep-sided submarine rise called Yaku-shinsone[1] (average depth 500 m.). The east and northeast coasts, of Yaku, the insular shelf, is very broad and continuous with that along the southern coast of Tane. The width of the insular shelf from east to west is estimated to be 33.6 km.

The Tokara (Linshoten) Group (See Imp. Japan. Nav. Charts, Nos. 182a, b, and 1.222).

The Tokara group comprises a number of volcanic islands disposed in a N. N. E. and S. S. W. direction west of the Ôsumi group and the Tokara Strait. Of these, Iwô, Kuchinoerabu, and Suwanose (Lit. 23) are still active, while the others are either dormant or have recently become extinct. Numerous submarine banks of varied depths run in the same direction as the string or rows of volcanic islands. Takara and Kotakara rest on a submarine platform, 100 m. or less deep, and independent of the insular shelves around Amami and Yaku. None of the other volcanic islands and submarine banks have a common shelf, each rising independently from the deep sea-bottom, 800 m. or less deep. Tectonically, all the submarine banks seem to be similar to the volcanic islands. The volcanic islands as well as the submarine banks of the Tokara group are arranged in parallel rows. In the front row belong the islands, Take, Kuchinoerabu, Kuchi, Naka, Suwanose, Akuseki, Kotakara, Takara, Kaminone, and Yokoate, as well as the submarine banks, Nakanosone[2] (151 m. deep) and Kaminose[3] (53 m. deep) lying between Kuchinoerabu and Kuchi; Tairase (=Terase)[4] (28 m. deep) and Nakanosone (21 m. deep) north of Takara, an unnamed deep bank (135 m. deep) north of Kaminone; and the four other nameless submarine banks lying meridionally in Long. 128°40′ E., Lat. 28°27′ N. (98 m. deep), 28°12′ N. (252 m. deep), 28°00′ N. (391 m. deep), and 27°50′ N. (71 m. deep). The middle row, 13 km. distant from the outer one, comprises the islands, Iwô, Kogaja, and Taira, besides a number of submarine banks; Mese[5] (14 m. deep) west of Kuchi, and three other unnamed submarine banks, one of which lies west of Akuseki (279 m. deep) and the remaining two (168 m. and 82 m. deep respectively) lying northwest of Kotakara. The inner row comprises Gaja and several submarine banks, Yuse[6] (67 m. deep) west of Iwô, Umekichisone[7] (148 m. deep) west of Kuchinoerabu, Sangosone (106 m. deep) west of Kuchi, Gonsone[8] (80 m. deep) south of Gaja, Gogôsone[9] (162 m. deep), Nakanosone[10] (93 m. deep), and Yokogansone[11] (65 m. deep) west of Takara.

Other submarine banks, probably also volcanic in origin, which have been sounded west of the inner row, are more or less irregularly scattered about the sea-bottom 800 m. deep.

The volcanic zone of the Tokara group can be traced farther southwards to Tori, west of Toku, Aguni, Kume, another Tori north of Kume, and the Agincourt-Pinnacle group.

The submarine configuration around the inner volcanic zone of the Riukiu Islands suggests that the volcanic islands and submarine banks were built up after the formation of the inner deep depression of the Riukiu Islands. As stated elsewhere, volcanicity first broke out at a late part of the Shimajiri stage (the late Pliocene, the stage of deposition of the Shimajiri beds).

The depth of the Tokara (Cornett) Strait between Yaku and Amami, the greater part of which is as much as 2,000 m., shallows westward, being generally 1,000 m. or less around the Tokara group.

The Ôshima Group.

Amami-ô-shima and Its Dependent Islets (See Imp. Japan. Nav. Chart, No. 225).

The coastal features of Amami and its dependent islets, everywhere suggest ancient land-

1) 屋久新曾根, 2) 中ノ曾根, 3) 上ノ瀬, 4) 平瀬, 5) 芽瀬, 6) 湯瀬, 7) 梅吉曾根, 8) 權曾根, 9) 五號曾根, 10) 中ノ曾根, 11) 横ガン曾根.

submergence. Numerous embayments, comparable to the firths of Scotland, deeply encroach into the interior of the islands. Amami is roughly triangular in outline, elongated from N. E. to S. W.; its east, west, and south coasts generally trending N. 40° E., N. 60° E., and N. 40° W. respectively. The islands have everywhere cliff-type coasts, there being no coastal terraces except along the coast of the Kasari[1] Peninsula, northeast of the isthmus of Akaoki.[2] Narrow, raised abrasion benches on the other hand are developed along the steep slopes or sea cliffs around all the coasts.

Amami and its dependent islets rest on a narrow insular shelf that suddenly broadens on the east coast of the Kasari Peninsula facing Kikai.

North of Naze[3] bay, the 400 meter submarine contour that is parallel to the general trend of the west coast of Amami (N. 60° E.) swings abruptly northward. This Naze bay, which is elongated from north to south, is open at the north. In the same manner, the 100 meter submarine contour on both the north and south sides of the isthmus of Akaoki swings abruptly from the normal trend (i. e., N. 40° E. along the east and N. 60° E. along the west coast) in a N.—S. direction. These submarine configurations, together with the outline of the island itself, are strong reminders that younger tectonic lines in a N.—S. direction longitudinally traverse Naze bay and the isthmus of Akaoki. Amami and its dependent islets are flanked by a narrow belt of fringing reefs, consisting chiefly of reef-building corals of luxuriant growth, its rims at low tide occasionally showing above the sea as belts of a dirty brown colour.

Kikai-jima (See Imp. Japan. Nav. Chart, No. 225).

Kikai, which is elongated in a N. E.—S. W. direction, rests on an insular shelf independent of that of Amami. Fringing reefs of 200 m. average width have formed on the shallower part of the shelf, while a submarine trough of 200 m. depth and, having the same trend as that of the longer axis of the island, divides the shelf of the island from that of Amami. The shelf is broadest in that part facing Amami, where it attains a width of 4 km. On the east and southwest sides of the island, are two flat-topped submarine rises, elongated in the same trend as that of the longer axis of Kikai, the easterly one having two reefs, Kadon-iwa[4] and Mori,[5] of 100 m. average depth, and the other with a reef, Ogame,[6] 40 m. deep. Although the former is separated from the insular shelf of the island by a broad trough, over 500 m. in depth and having the same trend as that of the longer axis of the rise, the latter is separated from the same by another trough 100 m. deep, in the same direction. From a study of the submarine topography and geological structure of the island, my opinion is that this island as well as the two submarine rises are horsts formed by a younger crustal-movement.

Toku-no-shima (See Imp. Japan. Nav. Charts, Nos. 182, 183).

The insular shelf of Toku-no-shima is almost continuous with that of Amami. The sea separating the two islands is 200 m. deep in the west and over 400 m. in the east. The broad shelf along the north and east coasts are 4 km. in width, the shallower part of which is incised by a submarine valley 100 m. deep and of an E.—W. trend off San Bay. Another deeper submarine valley with the same trend is traceable for more than 800 m., but its head, about 10 km. from the coast of Kamezu[7] is abruptly truncated by insular talus. The shelf is scarcely developed on the west coast.

Tori, a volcanic island that exploded in 1903 (Lit. 15), and lying 63 km. west of the village of Hedono[8] on the west coast, rises straight from the sea-bottom 800 m. deep.

A submarine bank, 71 m. deep, projects from sea-bottom of the same depth midway between

1) 笠利, 2) 赤尾木, 3) 名瀬, 4) 嘉鈍岩, 5) 森, 6) 御拝, 7) 龜津, 8) 平土野.

Toku and Tori.

Okierabu-jima (See Imp. Japan. Nav. Chart, No. 182).

The insular shelf that surrounds Okierabu is more or less broader on the northeast, southwest, and south coasts than on the other coasts; its outer edge plunging straight into a deep sea-bottom of 600 m.

Yoron-jima (See Imp. Japan. Nav. Chart, No. 182).

The minimum depth recorded from the sea between Okierabu and Yoron is 874 m. In this island, the insular shelf is developed only along the north and east coasts, none being seen along the south and west. A flat-topped submarine rise, 400 m. deep, extends southwards from the island to Okinawa, while another, 600 m. deep, extends northwards from the island.

The Okinawa Group (See Imp. Japan. Nav. Charts, Nos. 222, 226, 229, 233, 240, 242, 243.)

There is no insular shelf along the east coast of Okinawa in the stretch from north Kawada[1] to Hedo-zaki[2] in Kunigami-gun, although there is a submarine shelf, 120 m. deep, developed along the same coast from Kawada to Kyan-zaki,[3] the southern end of the island. This shelf is carved by six submarine valleys, traceable generally to depths of 400 m., but occasionally to about 1,000 m. as in the southeast of Ôura-wan[4] (Bay), Kushi-wan,[5] Kanna,[6] and Ike-banare, and as in the east of Ukibaru, the southeast of Tsuken-jima, and south of the village of Gushichan.[7] Along the west coast of the island, north of the Motobu Peninsula, are developed two successive submarine terraces, the shallower of which is 100 m. deep and the deeper 250 m., the two being separated from each other by a distinct linear scarp extending from Hedo-zaki, the northern end of the island, to Bise-zaki,[8] the northwestern corner of the Motobu Peninsula. Two islets, Kouri and Wô, rest on the shallower terrace. Along the west coast of the Motobu Peninsula, extends a submarine shelf 100 m. deep, on which rest Sesoko and Minna. Between the south of the town of Nago[9] and Zampa-misaki[10] are two successive submarine shelves, one of which is 100 m. deep and the other 300—500 m. deep.

Kume, Tonaki, the Kerama subgroup, and the Kê islets rest on a broad submarine shelf, extending westward from the west coast of Okinawa between Zampa-misaki and Kyan-zaki. Although the north border of the shelf runs linearly in an E.—W. trend, north of Tonaki it deviates north-westward and then turning westward again, runs along the north side of the eastern barrier reef of Kume. Since the sea-bottom along the north coast of Kume abruptly descends more than 1,000 m., even the 700 m. submarine contour line along the same coast is separated from the strand line by not more than 400 m. The 600 m. submarine contour along the same coast of the island swings north-eastward at the east end of the eastern barrier reef. Except along its west coast, where a deep sea basin north of Kume lies very close to it, a broad insular shelf, independent of the one just mentioned, is developed around Aguni.

South of Kume and Tonaki, the shelf on which these two islands rest is broadly developed and deeply incised by a submarine valley which, south of the village of Gima (or Jima)[11] in Kume, may be traced to a depth of 700 m.

Tori, a volcanic island lying 18 km. north of Kume, has its own small insular shelf, which is elongated from northeast to southwest and is 100 m. in depth. It is separated from the insular shelves of Okinawa as well as that of Aguni by a deep sea basin 1,000 m. deep.

1) 川田, 2) 邊土崎, 3) 喜屋武崎, 4) 大浦灣, 5) 久志灣, 6) 漢那, 7) 具志頭, 8) 備瀨崎, 9) 名護, 10) 残波岬, 11) 儀間.

The Iheya subgroup lies on an independent insular shelf, separated by a deep sea over 300 m. from those of Okinawa and Aguni.

The Miyako Group (See Imp. Japan. Nav. Charts, Nos. 241, 1204).

The Miyako group is separated by a deep sea of more than 1,000 m. from the Okinawa group. The former is divisible into two subgroups, the one including Miyako, Irabu, Shimoji, Kurema, and Ikema, and the other, Minna and Tarama. Each subgroup, which rests on an independent submarine shelf, 100 m. deep, is divided by a linear submarine trough over 200 m. in depth situated equidistantly between Shimoji and Tarama and having a N.N.W.—S.S.E. trend.

The extreme widths of the Miyako shelf are 32 km., 24 km., 9.2 km., and 6 km. on the east, west, north, and south coasts respectively. The shelf of the south coast which is generally 2.7 km. in width, broadens suddenly near the southeastern end of the island to a width of 6 km. In other words, the outer margin of the shelf deviates abruptly from its general E.—W. trend to a N.W.—S.E. trend near the southeast end of the island. According to Mr. R. Aoki, this abrupt change in the width of the shelf is the result of late crustal disturbances, as may be inferred from a tectonic line with a N.W.—S.E. trend that runs along the eastern border of a ridge to the west of Fukusato.[1)]

North of Irabu is a submarine valley, whose depth is traceable to as much as 600 m. in its lower course, but which, in its upper part, is abruptly delimited by insular talus at a depth of 300 m.

The width of the insular shelf of Tarama and Minna is 6.6 km. east of Tarama, 16 km. north of Minna, 9.6 km. south of Tarama, and 8.7 km. west of Minna. The eastern margin of the shelf, which is delimited by the linear submarine trough east of Tarama, descends more or less abruptly to a sea of more than 1,000 m. depth, east of Minna.

The Yaeyama Group (See Imp. Japan. Nav. Charts, Nos. 119, 1206, 1207).

The Yaeyama group is separated from the Miyako group by a deep sea basin nearly 400 m. deep. The islands of Ishigaki, Iriomote, Taketomi, Kuro, Kayama, Hatoma, Aragusuku-kanji, Aragusuku-shimoji, and Hateruma rest on one and the same insular shelf. Nakanogan, a small rocky uninhabited islet, is separated from the above cited island group by the sea, which is 300 m. deep, and rests on another independent insular shelf. Yonaguni is also isolated from those islands by a sea 300 m. deep, and from Taiwan by a sea 800 m. deep or slightly less.

The rim of the insular shelf of Ishigaki, Iriomote, etc., is almost defined by a 100 m. submarine contour, and runs subparallel with the coastal lines of the islands. The submarine shelf, which is covered by coral reefs, and lying between Ishigaki and Iriomote, is generally shallower than 40 m. On the south, the shelf is not only delimited by a steep scarp that descends to a deep sea bottom, but is deeply incised as well by three steep-sided submarine valleys down to a depth of 400 m. west of Aragusuku, to the east of Kuro and between the two islets. While the valleys are abruptly beheaded by coral reefs, their lower courses can be traced southward to as great a depth as 1,000 m. nearly.

A number of embayments deeply encroach into Iriomote on its west coast. North of this coast, the rim of the insular shelf runs in a N.E. and S.W. trend, while the 300 m. submarine contour that runs with the same trend deviates northwestwardly in the west of Soto-banare[2)] for a distance of 1.8 km. and then turns again northeastwards. This local deviation coincides exactly with the trend of the linear northern border of the embayment of Funauke[3)] and the straight south coasts of Uchi-banare[4)] and Soto-banare. It is well to be reminded that these topographical features, both above and below the sea, are closely related to a late tectonic movement. Many submarine

1) 福里, 2) 外離, 3) 船浮, 4) 内離.

valleys that are on the extension of the embayments on the west coast of Iriomote, incise into the insular shelf to as much as 70 m. or more and occasionally more than 200 m. A deeper submarine furrow that was found west of Sonai[1] is abruptly beheaded by insular talus at a depth of 200 m.

The insular shelf surrounding Yonaguni, which is very narrow, is also flanked by another deeper submarine platform 400 m. deep. South of the island, the latter is incised by a submarine valley, the lower limit of which is traceable to a depth of 500 m.

The Ôagari (Daitô) Group (See Imp. Japan. Nav. Chart, No. 1210).

The Ôagari (Daitô) group comprises three isolated islands, namely Kita-, Minami-, and Oki-ôagari (North and South Borodino and Rasa Island respectively). East of Miyako and Okinawa, it is separated from the main islands of the Riukiu Group by the Riukiu Trench, known for its maximum recorded depth of 7481 m. In profile, every island displays a truncated cone. Encircled by a narrow insular shelf 100 m. deep, these islands rise sheer from the oceanic bottom more than 1,000 m. deep.

Summary.

Most of the islands of the Riukiu Archipelago are surrounded by insular shelves reaching to 100 m. in depth. The Ôsumi group, which rests on one and the same insular shelf as Kyûshû, is separated from the Ôshima group by the Tokara Strait, 2,000 m. in depth. Amami, Toku, and Kikai are separated from one another by seas 200 m. or more deep. The minimum depth of the sea between Toku and Okierabu is 600 m. The latter island is separated from Yoron by a sea at least 874 m. deep. Okinawa, Kume, Tonaki, the Kerama subgroup, and the Kê islets rest on one and the same insular shelf, which is separated from that of Aguni by a sea 800 m. deep and from that of the Iheya subgroup by a sea 300 m. deep. The sea between the Okinawa and the Miyako group has a depth of over 1,000 m. The Miyako group is divided by a sea 400 m. deep from the Yaeyama group. Of the latter group, Ishigaki, Iriomote, Hatoma, Hateruma, Kayama, Aragusuku-kanji, Aragusuku-shimoji, Kuro, and Taketomi rest on one and the same insular shelf. Both Nakanogan and Yonaguni are separated from the above named islands by a sea over 300 m. in depth. Between Taiwan and Yonaguni is a sea basin 800 m. deep.

Careful studies of the surface of the insular shelves of the Riukiu Islands reveal three successive stages, namely the shallowest, which ranges from 0 to 10 m. in depth, the middle, with a range of 20—50 m., and the deepest, 70—100 m. The first is the general surface of the living coral reefs, i. e., the reef platform. Some sinuous furrows, which I am convinced are drowned valleys, are developed on the second in places.

The Ôsumi, the Ôshima-Okinawa, and the Sakishima group are separated from one another by a deep sea basin over 1,000 m. deep, while the sea basins between Yoron and Okinawa and between Yonaguni and Taiwan, as already mentioned, are all over 800 m. in depth. As these deep sea basins are developed across the general strike of the Paleozoic formation of the Riukiu Cordillera, they may be regarded as faults or rifts, as supposed by Dr. B. Kotô (Lit. 5). In the Riukiu Islands, a tectonic disturbance that occurred in the post-Shimajiri stage caused the Shimajiri beds to fold and fault, while another later block movement during the post-Kunigami stage tilted the Riukiu limestone along with the Kunigami gravel. The submarine configuration around the Riukiu Islands at the present time seems to be the results of these crustal disturbances.

Stratigraphy of the Riukiu Islands.

The geological formations so far distinguished in the Riukiu Islands are as follow, in

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descendig order:

Recent Deposits
Raised Coral Reefs and Raised Beach Deposits
Kunigami Gravel[1]
Riukiu Limestone[2]
Sonai Conglomerate[3]
Shimajiri Beds[4]
Yaeyama Coal-Bearing Beds[5]
Miyara Beds[6]
Palaeozoic Formation

Palaeozoic Formation. Palaezoic, the oldest formation in the archipelago, consists of slates, sandstones, schalsteins, conglomerates, phyllites, crystalline schists, radiolarian cherts, and crystalline limestones, some of them intruded by igneous masses in several places. Although S. TOKUNAGA (Lit. 12) assigned this complex to the Palaeozoic, owing to its stratigraphical and lithological resemblance to the Palaeozoic Chichibu System of the other larger islands of Japan, for a long time no palaeontological evidence in support of his assumption was available. The radiolarian cherts contain radiolaria, which are, however, recognizable only as minute lucid spots in thin slices of the rock, hence of no particular geological significance. The only fossils of any use for age determination are the foraminifera that I (Lit. 50) very recently found in a semi-crystalline limestone, interbedded in slates and cherts about 500 m. south of Tamagusuku[7] Nakijin-mura[8] (in the Motobu Peninsula) Okinawa. The foraminifera distinguished, which are *Neoschwagerina* sp. *Palaeofusulina* (=*Pseudofusulina*) sp. and *Verbeekina douvillei* (DEPRAT) point to Permian as the age of the limestone. The Palaeozoic formation of the Riukiu Islands is intensely folded and frequently overthrusted; slates and sandstones being often dynamically metamorphosed into phyllites and crystalline schists and also, occasionally, as in Okierabu, Toku, and Amami, contact-metamorphosed to spotted slates and hornfelses. This formation is found in Amami, Toku, Okierabu, Yoron, Okinawa, Kouri, Ie, Sesoko, Yagaji, the Iheya subgroup, the Kerama subgroup, Ishigaki, Taketomi, Iriomote, Kobama, and Kayama. The general strike of the formation is N. N. E.—S. S. W. in the Okinawa-Ôshima group and E.—W. in the Yaeyama group; the strata generally dips westward in the former group and northward in the latter, although there are some local deviations.

Yaku is composed mostly of a granite mass, surrounded by a narrow coastal belt of slates, sandstones, and conglomerates. According to Mr. NISHIWADA (Lit. 4) the sedimentaries are older than the granite, the former being intruded and contact-metamorphosed by the latter. F. VON RICHTHOFEN (Lit. 14, p. 949) inferred that the sedimentaries were Palaeozoic. Although these sedimentaries were coloured as Palaeozoic (in 1895) and Mesozoic of unknown age (in 1902) and Cretaceous (in 1926) on the Geological maps of the Japanese Empire successively issued by the Imperial Geological Survey of Japan, the age of these rocks has not yet been definitely settled. The sedimentary group shows, as already stated by Mr. G. IMAMURA (Lit. 43), a steep monoclinal structure with its general strike in direction N.N.E.—S.S.W. Some contact rocks are found widely separated from the granite mass as the result probably of later dislocation. Lithologically and geologically, the sedimentary group is quite similar to the Palaeozoic formations found exposed in Amami, Toku, Okierabu, and the other islands of the Riukiu group. In all probability therefore the sedimentary group of Yaku is Palaeozoic in age, not Mesozoic.

The next younger formation is the Miyara beds (Upper Eocene), which occurs only in the two

1) 國頭礫層, 2) 琉球石灰岩, 3) 租納礫岩, 4) 島尻層群, 5) 八重山炭層群, 6) 宮良層群, 7) 玉城, 8) 今歸仁村.

islands, Ishigaki and Kobama in the Yaeyama group, resting upon the erosional surface of intensely folded Palaeozoic formation. No Mesozoic and Lower Eocene rocks have hitherto been reported from the Riukiu Islands. During Mesozoic and Lower Eocene times, the Palaeozoic rocks were intruded by ignerous masses, accompanied probably by folding, and afterwards again intensely deformed and later subjected to prolonged subaerial denudation. In the absence of Mesozoic formations in the Riukiu Islands, there is no material for determining the precise ages of the igneous intrusion and of the deformation.

Miyara Beds. These beds, which rest on an erosional surface of the intensely folded Palaeozoic formation in Ishigaki and Kobama as just stated, consist mostly of hard compact limestones, with subordinate sandstones and conglomerates. The limestones contain well preserved foraminifera characteristic of the Upper Eocene, such as *Pellatispira madraszi* HANTKEN, *Camerina* sp., and *Discocyclina* sp. as already reported by Prof. H. YABE (Lit. 21). Besides foraminifera, *Archaeolithothamnium*, *Lithothamnium* and other calcareous algae are abundant. The sandstones are light-brown, mostly medium grained, and loose in texture, while the conglomerates are variegated and generally hard, with either round or angular pebbles of Palaeozoic slates and sandstones, granitic rocks, and vein quartz. The Miyara beds are tilted in various directions at steep angles.

The Yaeyama coal-bearing beds, which lie next to the Miyara Beds, is an equivalent of the Kaizan beds in Taiwan, having a fossiliferous zone of Burdigalian age near its base as stated below. Following the deposition of the Miyara beds, a long break occurs in the sequence of formation, the break covering the Periods of Stampian and Aquitanian, which, though well developed in the Philippines and in the East Indies and adjacent regions, are found neither in the Riukiu Islands nor in Taiwan. This stratigraphical hiatus may represent a period of extensive subaerial denudation, called by Prof. H. YABE and R. AOKI (Lit. 25, pp. 964, 965) the Takachiho Period of Emergence. It is a noteworthy fact that, in striking contrast to the case in Taiwan, where the Palaeogene rocks are partly metamorphosed into crystalline schists, the Eocene formation of the Riukiu Islands is merely dislocated, never metamorphosed.

Yaeyama Coal-Bearing Beds. These beds occur in Yonaguni, Iriomote, Hatoma, Kobama, Ishigaki, Hateruma, and Nakanogan in the Yaeyama group. They are formed of andesite lavas, andesitic tuffs and agglomerates in the lower part, passing upwards into an alternation of soft light-brown sandstones and gray shales with intercalations of some workable coal seams. The sandstones are occasionally cross-bedded. In Yonaguni, an impure limestone, lying above a coal seam, contains *Operculina* cfr. *bartschi* CUSHMAN var. *multiseptata* YABE and HANZAWA besides ill preserved molluscs and echinoids. S. TOKUNAGA (Lit. 12, p. 51) found *Astriclypeus integer* YOSHIWARA in Soto-banare of Iriomote. These fossils are characteristic of the lower part of the Kaizan beds of Taiwan. The Yaeyama coal-bearing beds may be correlated with the lower part of that formation, which is Burdigalian in age. This formation, which is only slightly tilted, is cut by numerous faults.

Shimajiri Beds. These beds occur in Kikai, Okinawa, Henza, Taka, Ike, Hamahiga, Kume, and Miyako, and consist of soft bluish-gray marls and soft brownish sandstones; both the marls and sandstones have occasionally hard marly nodules as large as 1 m. in diameter.

The bluish-gray marls are generally very fine grained, greasy to the touch and disintegrating easily in water, besides abounding in the remains of microscopic organisms, foraminifera (mainly pelagic forms), Coccolithophorids, Discoasterids, sponge spicules, and radiolaria. The marls are comparable with the Blue Mud of recent oceanic deposits. Locally, the marls and sandstones contain, besides foraminifera, etc., minute molluscs and solitary corals. The very prolific Shimajiri marls from Nakôshi, Okinawa, contain, besides mollusca, abundant remains of foraminifera,

Operculina bartschi CUSHMAN, *Operculinella venosa* (FICHTEL and MOLL) and other minute forms as already reported by H. YABE and myself (Lit. 28). These marls are also mixed with a number of well rounded small pebbles of Palaeozoic rocks. The Shimajiri beds in Kume, which differes in lithological character from those found in the other islands, is composed of light-yellow tufaceous sandstones and bluish-gray shales, often cross-bedded and containing mollusca, bryozoa, and foraminifera. Among my collection of mollusca, Mr. S. NOMURA identified *Pecten satôi* YOKOYAMA, characteristic of the Byôritsu beds of Taiwan. According to him, the molluscan fauna in the Shimajiri marls from the Motobu Peninsula, Okinawa, is quite similar to that of the above-mentioned beds of Taiwan. On the whole, the Shimajiri beds of the Riukiu Islands show a remarkable likeness in lithological character and condition of sedimentation to the Byôritsu beds of Taiwan.

In Kume, the sandstones and shales mentioned above are succeeded by andesite lavas and agglomerate without any stratigraphical break. In Kikai, the Shimajiri marls intercalate a pumice layer in the upper horizon - all evidences that the volcanic activity of the inner zone of the Riukiu Islands began in the late Shimajiri stage.

The Shimajiri beds either directly overlie the eroded surface of the Palaeozoic formation in Okinawa or form foundation rocks in Kikai, Kume, Miyako and the dependent islets of Okinawa, in which no other older formation occurs. Though its stratigraphical relation to either the Yaeyama coal-bearing beds or the Sonai conglomerate stated below is not certain, since the three formations do not occur together in one and the same island, it may readily be supposed that the Shimajiri beds are younger than the Yaeyama coal-bearing beds, seeing that the former may be correlated with the Byôritsu beds and the latter with the Kaizan beds as already mentioned. It is possible that the Shimajiri beds are older than the Sonai conglomerate, and that the latter is correlated with the Shokkôzan conglomerates of Taiwan.

Sonai Conglomerate. This formation, which occurs only east of Sonai[1] in Irimote and at the north end of Uchi-banare, is composed of well rounded pebbles and boulders of hard sandstones and limestones of diameter usually 10—20 cm. occasionally as large as 2 m.

Slices of the limestone-block contain the following forminifera :

Lepidocyclina (*Nephrolepidina*) *taiwanensis* YABE and HANZAWA,
Miogypsina inflata YABE and HANZAWA,
Gypsina globulus REUSS,
Cycloclypeus communis MARTIN (=*C. eidae* TAN SIN HOK),
Amphistegina radiata (FICHTEL and MOLL).

These species are characteristic of the Kaizan beds of Taiwan, which are contemporaneous with the Yaeyama coal-bearing beds. The Sonai conglomerate is in contact with the last mentioned beds by a fault plane, both near Sonai and at the north end of Uchi-banare, and, at the former place, covered unconformably by the Riukiu limestone. These seem to be evidences that the Sonai conglomerate is younger than the Yaeyama coal-bearing beds, but older than the Riukiu limestone.

S. TOKUNAGA (Lit. 12, p. 48) reported having found a thin layer of a *Lepidocyclina*-limestone interbedded in the coal-bearing Tertiary, east of Sonai, Iriomote, but I failed to find the limestone-layer, my efforts notwithstanding, although I did find these limestones in blocks of the Sonai conglomerate. As reported by NEWTON-HOLLAND (Lit. 13) and YABE-HANZAWA (Lit. 28, pp. 30, 31), the limestones collected by S. TOKUNAGA contain the same species of forminifera and possess lithological characters similar to those of the Sonai conglomerate. The possibility is not remote however that S. TOKUNAGA's collection was derived from the huge blocks of limestone that outcrop

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in the conglomerate, and not from a layer interbedded in the Yaeyama coal-bearing beds.

The hard sandstone, found as boulders in the Sonai conglomerate, differs entirely from the sandstones of the Palaeozoic, the Miyara, or the Yaeyama coal-bearing beds. Despite my strenuous efforts to trace the source of the hard sandstones, as well as the *Lepidocyclina*-limestone of the Sonai conglomerate, in the Riukiu Islands, I failed to do so.

As already stated, the question as to whether the Sonai conglomerate should stratigraphically be placed above the Shimajiri beds or below it cannot definitely be answered so far as my present knowledge of the stratigraphy of the Riukiu Islands and Taiwan goes. All I can say is that the Sonai conglomerate is probably contemporaneous with the Shokkôzan conglomerates of Taiwan.

Riukiu Limestone. This limestone, which is extensively developed in every one of the Riukiu Islands except those belonging in the Tokara, Ôsumi, and Kerama groups, and Tonaki, Iheya, Izena, and Nakanogan, rest unconformably on the Palaeozoic, Miyara, Yaeyama coal-bearing, Shimajiri, and Sonai formations. Although we have no conclusive evidence with which to settle the geological age of the limestones constituting the Ôagari group, there are possibilities of the limestones being correlated with the Riukiu limestone. The marked unconformity between the Riukiu limestone and all the preceding older formations represents a prolonged and extensive period of subaerial denudation, to which I give the name - post-Shimajiri stage.

The Riukiu limestone, which is mostly hard and cavernous, is often loose and incoherent and cross-bedded in places. It is also white or light yellow, and contains a great number of coral reef organisms, such as reef-building and deep-sea corals, foraminifera, bryozoa, brachiopoda, mollusca, echinoids, and calcareous algae. The organic contents of these rocks differ considerably with the locality, foraminifera preponderating in some places and reef-building corals in others.

The dominant foraminifera species found in this limestone are

Acervulina inhærens SCHULTZE var. *plana* CARTER,
Alveolinella quoyi D'ORBIGNY,
Amphistegina radiata (FICHTEL and MOLL),
Baculogypsina sphaerulata (PARKER and JONES),
Baculogypsinoides spinosus YABE and HANZAWA,
Calcarina spengleri (LINNÉ) (=*Tinoporus baculatus* MONTFORT ?),
Cycloclypeus gümbelianus-carpenteri BRADY,
Heterostegina depressa D'ORBIGNY,
Homotrema rubrum LAMARCK,
Miniacina miniacea (PALLAS),
Operculina bartschi CUSHMAN.

Of these, the *Baculogypsinoides spinosus* YABE and HANZAWA has not yet been recorded from any of the seas north of the Philippines. *Cycloclypeus gümbelianus-carpenteri* BRADY, the most predominant species in the Riukiu limestone, has not yet been found in the shore sands of the Riukiu Islands, although I (Lit. 34, p. 67) once found it in bottom material dredged from the insular shelf east of Okinawa.

A molluscan species, bearing close affinity to either *Pecten naganumanus* YOKOYAMA or *Pecten sinensis* SOWERBY and a brachiopod species *Pictothyris hanzawai* YABE (Lit. 49), are more or less widely distributed in this limestone. An alcyonarian coral species, *Tubipora rubiola* QUOY and GAIMARD is found in the limestone as far north as Kikai, while this genus or species does not inhabit the seas of the Riukiu Islands, being found only in Taiwan and the Ogasawara[1] (Bonin) group.

(1 小笠原.

The occurrence of *Baculogypsinoides spinosus* and *Tubipora rubiola* in the Riukiu limestone suggests that the climate of the Riukiu Islands in the Riukiu stage, during which the Riukiu limestone was formed, must have been somewhat warmer than at present.

The basal part of the Riukiu limestone occasionally contains abundant pebbles derived from the underlying formations. The Riukiu limestone of Toku is peculiar in that its upper half does not differ from the normal facies of the limestone in the other islands, whereas the lower half is made up of incohrent non-calcareous sand and gravel. The latter passes upwards more or less suddenly to the former, although without any stratigraphical break.

I (Lit. 29, p. 9) wrote in an earlier paper that the Kunigami gravel, mentioned below, to be a deposit contemporaneous with the basal conglomeratic part of the Riukiu limestone, but my recent field observations have shown that, instead, the Kunigami gravel unconformably covers the Riukiu limestone.

As the Riukiu limestone suffered subsequent erosion, it is difficult to know its original thickness. Its maximum thickness is estimated however to exceed scarcely 100 m. The lower arenaceous part of the same limestone of Toku is estimated to be 60 m. thick.

The Riukiu limestone is generally horizontal, although frequently it is tilted slightly as is the Kunigami gravel.

The geological age of the Riukiu limestone was once believed by S. TOKUNAGA (Lit. 12) to be Pleistocene, although H. YABE and I (Lit. 28, p. 37) regarded it as of pre-Pleistocene (Glacial) age. Although there is no data by means of which the precise geological age could be settled, seeing that the overlying Kunigami gravel belongs in the Shikishima series (Lit. 25, p. 565) and the underlying Shimajiri beds in the Mizuho series (Lit. 25, p. 568), the limestone formation may be either Upper Pliocene or Lower Pleistocene.

Kunigami Gravel. Throughout the extent of the Riukiu Islands, high successive terraces, strewn in place by gravel beds a few meters thick, are extensively developed along the coasts, beveling all preceding formations. They are occasionally 200 m. or more in height, although those of 80—100 m. in elevation are most extensive, and as a rule greatly dissected by valleys. The change in slope between the mountain slopes in the background and the surface of the highest terrace is in many places generally abrupt. The gravel beds that cover the terraces are called Kunigami gravel.

The Kunigami gravel is generally composed of lateritic soil and round pebbles of rocks of preceding formations, derived from the mountains behind and from the foundation of the terraces. Usually red or brown on the surface, they are often interbedded with bands of sand and clay of light-brown or bluish-gray colour. Numerous manganese nodules, 5—15 mm. in diameter, and showing a concentric structure, are found in the Kunigami gravel near Zamami,[1] Nakagami-gun, Okinawa, and in the western part of Kume.

In Yaku, Mr. IMAMURA (Lit. 34, p. 19) discovered huge exotic blocks of pumice in a terrace deposit covering a coastal terrace 100 m. above sea level. Messrs. R. AOKI, F. YAMANARI, and T. SUGIYAMA reported the occurrence of an exotic pumice-layer, covering a 70 m. coastal terrace in Kita-Ôagari. In their elevations, these terraces of Yaku and Kita-Ôagari may be correlated with the high level terrace of Okinawa and the other islands. Although no marine fossils have yet been discovered in the Kunigami gravel, the manganese nodules in Okinawa and Kume, the exotic pumice-blocks in Yaku and Kita-Ôagari, and the character of the high level terraces all forcibly suggest that the high level terraces are the result of marine abrasion and that the Kunigami gravel was deposited in sea water. If the high level terraces are due to marine abrasion, then the sea that cut them must

1)

have been a non-coral sea. Though Yonaguni, Hatoma, Hateruma, Taketomi, and Miyako are destitute of Kunigami gravel, the level terraces in them corresponding in height to those of the other islands are well defined. If we may ascribe the origin of the high level terraces of the Riukiu Islands to marine abrasion, then the Riukiu Islands were extensively invaded by the sea in the Kunigami stage (when the Kunigami gravel was deposited). As the high level terraces cut obliquely the Riukiu limestone and the older formations, it is only reasonable to suppose that there was once a land stage prior to the marine invasion of the Kunigami stage. For this land stage, I propose the name - post-Riukiu stage.

We must consider the existence of another land stage, immediately following the marine invasion of the Kunigami stage, during the stage in which the Kunigami gravel was raised above sea level and tilted together with the Riukiu limestone. This land period is called the post-Kunigami stage, a stage during which the land was highly dissected. After that a great positive shift of sea level occurred throughout the Riukiu Islands, when the land-submergence topography, as we now see in the island group, was formed and the raised coral reefs and their equivalent deposits (described below) were developed as fringing reefs and littoral deposits, respectively.

Raised Coral Reefs and Raised Beach Deposits. Raised Coral Reefs, consisting principally of reef corals, along with other subordinate reef organisms, are typically developed along the shores of Kikai and Kume, where they form the lowest coastal terraces, the surfaces of which slope very gently to sea level from an elevation of 20 m. That is to say, their seaward edges are often directly connected with the recent fringing reefs, so that it is impossible to draw a sharp line of demarcation between them.

In the other islands, except along the coasts where the Riukiu limestones plunge straight into the sea, narrow raised abrasion benches, equivalent to the raised coral reefs of Kikai and Kume, are uniformely developed. In the latter case, the Riukiu limestone forms vertical cliffs, in which tidal marks, sea caves, and niches are cut by wave action ; no raised abrasion benches being found. The raised abrasion benches that bevel the older beds, are frequently coated with a veneer of calcareous deposits, composed of fragmental reef corals, foraminiferal test, and other reef organisms.

The reef organisms found in the above-mentioned deposits are quite similar to those of the recent fringing reefs of the Riukiu Islands.

The dominant foraminifera forms are

Amphistegina radiata (FICHTEL and MOLL),
Acervulina inhærens SCHULTZE var. *plana* CARTER,
Baculogypsina sphaerulata (PARKER and JONES),
Calcarina spengleri (LINNÉ) (=*Tinoporus baculatus* MONTFORT ?),
Heterostegina depressa D'ORBIGNY,
Miniacina miniacea (PALLAS).

Foraminifera so common in the Riukiu limestone, such as *Cycloclypeus gümbelianus-carpenteri* BRADY, *Baculogypsinoides spinosus* YABE and HANZAWA and *Operculina bartschi* CUSHMAN are not represented in them.

Sand Dunes. In Kikai, Amami, Kume, and the other islands, sand dunes are developed both along the shore and inland. They are principally composed of foraminiferal tests, which are occasionally found consolidated into soft limestone. Sometimes these limestones are scarcely distinguishable from the Riukiu limestone, although the former are generally rich in remains of land snails not found in the latter.

Geological History of the Riukiu Islands.

The geological history of the Riukiu Islands begins with the Permian Period. The marine Permian formation was intruded by igneous rocks during late Permian or early Mesozoic time, thus forming the nucleus of the future Riukiu Cordillera. After a long period of subaerial denudation, the older rocks suffered from crustal movements during a certain part of the Mesozoic Era; that is, they were in parts contorted, faulted, and regionally metamorphosed into crystalline schists and phyllites. The great Riukiu Cordillera thus arose very nearly from the present site of the Riukiu Islands. Owing to the absence in these Islands of any formation younger than the Permian and older than the Upper Eocene, the exact age of the intense crustal deformation is uncertain. The Riukiu Cordillera, after subjection to prolonged subaerial denudation, was divided into a number of mountain masses. Long after the subaerial denudation, the erosional surface of the Permian formation was transgressed by the sea in the Akitsu Period (the Japanese Palaeogene) (Lit. 25), during which the Miyara beds, comprising the *Pellatispira*-limestones of Ishigaki and Kobama, were deposited.

Stampian and Aquitanian rocks are missing both in the Riukiu Islands and in Taiwan. During these periods orogenesis, dynamo-metamorphism, and marine regression occurred in Taiwan. In the Riukiu Islands during the same periods, similar land conditions prevailed, while the Miyara beds were tilted and denuded, but not metamorphosed. These stages correspond to the Takachiho Period of Emergence (Lit. 25).

During the Neogene (the Mizuho Period of Submergence) (Lit. 25), excluding the Aquitanian stage, the Riukiu Cordillera was widely inundated by the transgressing Neogene sea, in which the sediments of the Yaeyama coal-bearing beds, the Shimajiri beds, and the Sonai conglomerate were laid down in upward succession. The Yaeyama coal-bearing beds comprise volcanic material in its lower part and the Shimajiri beds the same in its upper part, so that during the Neogene, volcanic activities broke out twice in the Riukiu Islands. In Taiwan, the Kaizan beds, which are of the same age as that of the Yaeyama coal-bearing beds, are accompanied by basalt, andesite, and their tuffs in the lower part. According to Mr. K. TAN's recent geological studies of the Daiton volcanoes in the island itself, its volcanic activities began in the later part of the Byôritsu stage, during which the Byôritsu beds, correlative with the Shimajiri beds, were deposited.

In the post-Shimajiri stage, the whole series of the Neogene deposits were dislocated, although with less intensity than that during the post-Shokkôzan stage (the land stage immediately following that during which the Shokkôzan conglomerates were deposited) in the island of Taiwan. In the same stage, the Neogene sediments were extensively exposed to subaerial denudation. If we are willing to concede that the submarine valleys adjacent to the Riukiu Islands, Taiwan, Honshû, etc., and often traceable to as great a depth as 700 m. or more, were formed subaerially in this period, then we must admit that the Riukiu Islands were once elevated more than 700 m. above its present position. Prof. H. YABE (Lit. 35, p. 168) has already pointed out that in the last continental stage of the Japanese Islands, the entire region of Taiwan, the Riukiu group, Kyûshû, Shikoku,[1] Honshû,[2] Hokkaidô,[3] the Chishima[4] (Kurile) group, all lying within the 720 m. submarine contour line, were dry land connected with the Asiatic continent, while the easternmost part of the Tung-hai, the greater part of the Japan Sea, and the southernmost part of the Ochotsk Sea almost, if not entirely, were land-locked sea basins.

The geological history of the Riukiu Islands after the post-Shimajiri stage is largely bound up

1) 四國, 2) 本州, 3) 北海道, 4) 千島.

with the shifting of strand lines. The erosional land-surface of the deformed Neogene rocks was invaded by the advancing sea, in the shallower part of which the Riukiu limestone began as coral reefs, when the upper courses of the deep drowned valleys just-mentioned were either buried in some places or remained as coral reef-passages in others, just as we frequently find in the case of the recent coral reefs of the South Seas. In this stage, only the tops of Yaku, Takara, Kotakara, Amami, Toku, Okierabu, Okinawa, Kume, Iheya, Tonaki, Tokashiki, Mae, Yukan, Kuba, Ishigaki, Kobama, and Iriomote showed themselves as small islands above the water; all the other islands being submerged below sea level. Following this came the land-emergence when the Riukiu limestone showed above sea level, rejuvenating the topography. This was the post-Riukiu stage of emergence, during which Takara and Kotakara were united into a single island, and in the same way all the islands of the Ôshima-Okinawa group as well as those of the Sakishima group, into two other islands.

The erosional surface of the three large newly formed islands was again transgressed by a non-coral sea that cut the successive coastal terraces in its periodical retreats, leaving behind the Kunigami gravel on the terraces as beach and fluviatile deposits. At maximum inundation, the tops of only Yaku, Takara, Kotakara, Amami, Toku, Okinawa, Iheya, Kume, Tonaki, Tokashiki, Ishigaki, Kobama, and Iriomote remained as islands, all the other islands being entirely drowned in the sea.

A crustal disturbance that set in later tilted the Kumigami gravel along with the Riukiu limestone. In this, the post-Kunigami stage of emergence, Ishigaki was connected with Taketomi and Kuro; Okinawa with its dependent islets (excluding Tsuken and Kudaka); and Kume with its dependent islets; Iheya with Noho and Gushichâ; and Tokashiki with Kuro, Jifushi, Fukase, and Gusuku. The other islands were separated from one another by the sea. The seas lying between Okinawa and Miyako, between Yonaguni and Taiwan, between Yoron and Okierabu, and between Amami and Yaku and to the north of Kume, were in all probability deepened by the latest tectonic movement. As to the Tokara Strait between Amami and Yaku, however, with depth as much as 2,000 m. in its greater part, it is supposed that it was in existence even at the time of Prof. H. YABE's latest continental stage of the Japanese Islands as an opening, permitting communication between the land-locked sea inside the Riukiu Islands and the Pacific Ocean. This land connection in the post-Kunigami stage just mentioned is an inference based on the present submarine configuration of the Riukiu Islands.

The subsequent history of the Riukiu Islands resembles those of the island of Taiwan and the main islands of Japan, namely, that positive shift of sea level, 20 m. or less, occurred, resulting in land-submergence topography, with fringing reefs and their equivalent beach deposits formed around the newly submerged islands.

Later, the sea level shifted in a negative sense; the fringing reefs and beach deposites were elevated to heights of from 2 to 20 m. Recent coral reefs are to-day growing luxuriantly along the margins of all the islands south of the Tokara Strait.

The Ôshima Group

Amami-ô-shima and Its Dependent Islets.

Geographical Situation and Topographical Features.

Amami, with its dependent islets, Kakeroma, Uke, Yoro, Edato, Yu, and Sukomo, lies at the northern end of the Ôshima group, in Lat. 28°—28°32′ N. and Long. 129°07′—129°44′ E. Its longer axis, 57 km., runs N.E.—S.W. From 30 km., its maximum breadth at the south end, it tapers to Kasari-zaki its northernmost end. Kakeroma, 20 km. long, extends N. E.—S.W., while Uke is 7

km. long in the same direction and Yoro 6 km. from north to south.

South of Naze, the principal town of Amami, are six high parallel ridges in a direction perpendicular to the length of the islands, and separated from one another by deeply incised valleys that drown into the sea at their lower ends. Kakeroma and Uke are virtually two more ridges of the same system, the Ôshima straits between Amami and Kakeroma and the Uke straits between Kakeroma and Uke being nothing but interstitial valleys drowned deep below sea level.

To the north of Naze, are two high ridges of north to south trend, one forming the backbone of the Kasari Peninsula and the other lying west beyond a deep embayment, Kasari-wan, which opens northwards and is divided at the south into four minor embayments by three small peninsulas, Nishibaru,[1] Ton-zaki, and Maehida[2], all trending N.—S.

Amami and its dependent islets have cliff-type coasts, with the single exception of the coast of the Kasari Peninsula lying north of the isthmus of Akaoki. The mountains here almost everywhere slope down straight to the sea. There are no coastal terraces, such as are seen in Toku, extensive coastal terraces being well developed only along the east coast of the Kasari Peninsula and contiguous regions. All the high ridges on the islands have nearly the same height (400 m. on the average) with their summit levels gently sloping seawards. The greatest elevation, 690 m., is attained by Yuwan-dake[3], one of the ridges along the north of Yakiuchi-wan.[4] Along the foot of the sea cliff and below the coastal terrace, narrow raised abrasion benches, about 5 m. above sea level, are more or less uniformly developed.

The Kasari Peninsula and its adjacent region, lying between the isthmus of Akaoki and Ôgachi,[5] differ topographically from the rest of the island. A linear, broad ancient valley of a N. E.—S. W. trend that passes over Ôgachi is entirely submerged under the sea north of Ura,[6] southward of which it is dry land, drained by two streams of more recent origin, one emptying northwards in Kasari-wan and the other southwards in Toguchi[7] on the Pacific coast. The watershed between the two streams is fomed by a terrace slightly north of Ôgachi, 20—40 m. high, 600 m. wide, and already moderately dissected. The two streams have flood plains of sand and gravel. South of Ôgachi, a terrace 80 m. high is developed continuously along the east side of the valley and intermittently along its west side.

The foundation of the isthmus of Akaoki, which is 800 m. wide from north to south, 1500 m. wide from east to west, and 20 m. high, consists of non-calcareous sands covered with cross-bedded calcareous dune sands. Along both the east and west sides of the isthmus, a 40 m. terrace may be traced here and there, for example, from Ashitoku[8] to Toguchi beyond Nebaru[9] and Kasema[10] on the west, and from Akaoki to the tip of Ton-zaki on the east. Similar terraces are developed in the valleys of Kise[11] -Yoan,[12] Tekibu[13] -Taira[14] -Tsuchibama,[15] Akakina[16] -Wano,[71] and Yani.[18] The continuity of the backbone ridge of the Kasari Peninsula is broken by the transverse valleys of Kise – Yoan, Tekibu – Taira – Tsuchibama, and Akakina – Wano.

Along the east coast of the Kasari Peninsula, from Tsuchibama to a little north of Yô[19], a broad highly dissected terrace is developed, which terrace, upon close observation is divisible into two successive tiers, the higher of which is 80 m. high and 500 m. broad and the lower 40 m. high and 150 m. broad. The 80 m. terrace (the higher) crosses the flat-bottomed valleys just mentioned that traverse the backbone ridge of the Kasari Peninsula, being continuous with the terrace (near Tekibu and Akakina) that is developed on the west coast of the peninsula. The terraces on both the east and west coasts of the Kasari peninsula and in the valley of Ôgachi are covered with gravel,

1) 西原, 2) 前肥田, 3) 湯灣岳, 4) 焼内灣, 5) 大勝, 6) 浦, 7) 戸口, 8) 芦徳, 9) 根原, 10) 嘉徒間, 11) 喜瀬, 12) 用安, 13) 手木部, 14) 平, 15) 土濱, 16) 赤木名, 17) 和野, 18) 屋仁, 19) 用.

sand, and lateritic soil. Besides these terraces, sand dunes consisting of cross-bedded calcareous sand, are extensively developed along the coast from Wano to Tsuchimori[1] near Tsuchibama ; also north of Yô, near Saji,[2] as also south of Kasari-zaki.

Stratigraphy.

The geological formations exposed on Amami and its dependent islets are, in descending order :

Raised Beach Deposits and Sand Dunes
Kunigami Gravel
Riukiu Limestone
Palaeozoic Formation

Palaeozoic Formation. Most of the foundation rocks of Amami and its dependent islets are Palaeozoics, intruded in places by igneous rocks. Of these Palaeozoics, a black clay slate is most common, although thick massive sandstone, generally medium grained and sometimes containing flakes of black slates, are exposed between Yen[3] and Kato[4]. A conglomerate composed of round pebbles of granitic rocks, hard sandstones, and slates, 1 cm. or more in diameter, is found north of Tsuyo[5] in Kasari-wan and near Tsuchibama on the east coast of the Kasari Peninsula ; a schalstein occurs near a disused copper mine at Yanyû,[6] radiolarian cherts at Ôkaneku[7] and Imazato[8] in Yamato-mura,[9] gray crystalline limestones at Imazato and 1 km. west of Naon[10] in Yamato-mura ; also contact-metamorphic rocks, viz., hornfels and spotted slates at the west point of Asani[11] northwest of Naze, and 300 m. west of Toen[12] in Yamato-mura. Generally speaking, the strike of the Palaeozoic strata varies from N. to N. 10° E., while their dip is westward at different angles. Intensely folded, they are sheared by many overthrusts and pierced by innumerable veinlets of quartz, while in several places where they were greatly disturbed, the slates with quartz veinlets have altered to crush-conglomerates. The fact that these contact-metamorphic rocks lie quite a distance away from the igneous bodies exposed on the surface must be due either to the presence of an igneous mass concealed directly beneath them or to a displacement that pushed them away from their original position as a contact aureole. Probably the latter explanation is the more reasonable in this case, seeing that the entire region is greatly disturbed by faults and other dislocations. The radiolarian chert in the Palaeozoic formation is hard, compact, occasionally thin banded, and gray or dirty yellow. The crystalline limestone, which contains no organic remains, is hard, gray, compact, and homogeneous in texture.

Riukiu Limestone. As in Toku, no formation that is younger than Palaeozoic but older than the Riukiu limestone is to be found in the island. The Riukiu limestone, which is a formation of an age next above the Palaeozoic, is exposed along the coast from Yô to Kasari in the Kasari Peninsula, on the outer edge of the coastal terrace 40 m. in elevation and 300 m. in breadth. The Riukiu limestone, which is overlain by a thin gravel bed, consists chiefly of a light-brown, cross-bedded fine grained porous limestone that is occasionally full of stocks of reef-building corals, and conglomeratic at the base with round pebbles of Palaeozoic rocks.

Dr. S. Tokunaga (Lit. 12) reported the occurrence on the island of Raised Coral Reefs, but they are, in my opinion, mostly sand dunes, only one of them having been proved to be Riukiu limestone. Although the dune sands are very similar to the Riukiu limestone exposed from Yô to Kasari, the former is distinguished from the latter by its light-yellow colour, loose and incoherent texture, and by its containing many remains of land snails (mostly *Euhadra* sp.), an evidence of its being a terrestrial deposit.

1) 土盛, 2) 佐仁, 3) 圓, 4) 嘉渡, 5) 津代, 6) 屋入, 7) 大棄久, 8) 今里, 9) 大和村, 10) 名音 11) 朝仁, 12) 戸圓.

Kunigami Gravel. This is the gravel deposit that covers the 40 m. and 80 m. terraces just mentioned. It is composed of round and subangular blocks of Palaeozoic rocks, occasionally intercalated with sand layers. This gravel, which varies in thickness with place, is about 7 m. west of Kise and on the west side of Ton-zaki in the Kasari Peninsula, although as a rule it is much thinner, being 1—2 m. The greater part of the 80 m. terrace on the east coast of the Kasari Peninsula is free from gravel.

Raised Coral Reefs and Raised Beach Deposits. All the coast of Amami and its dependent islets are surrounded by narrow, raised abrasion benches coated with a veneer either of gravel derived from the cliffs lying behind them or of a calcarous deposit consisting of remains of lime secreting organisms, mainly foraminifera, and subordinate bryozoa, calcareous algae, and reef-building corals. This calcareous deposit may also be called raised coral reefs since they are formed mostly of reef-building corals, which are now growing very luxuriantly all around the islands, forming more or less wide fringing reefs. The raised coral reefs are almost continuous with the fringing reef in their outer margin.

Sand Dune. As already mentioned, coastal sand dunes are well developed in the Kasari Peninsula and the isthmus of Akaoki, in both of which places they reach 10 or 20 m. in height. The dune sand, which consists largely of calcareous forminiferal remains, is still unconsolidated.

Kikai-jima

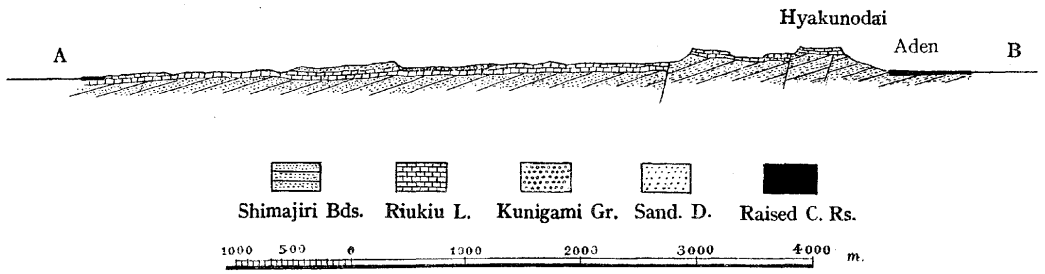
Geographical Situation and Topographical Features.

Although at one time called "Kikai-ga-shima," the present name of this ialand is Kikai-jima, the Kyâ of the natives.

Kikai lies 20 km. east of the Kasari Peninsula of Amami in Lat. 28°17′—28°23′ N. and Long. 129°54′—130°03′ E. Its longer axis, which is 12.5 km., lies almost N. E. and S. W. Near its southwestern end it is 5.5 km. broad, and tapers gradually to Tobiyo-zaki, the northeastern end of the island ; its narrowest part, 2.3 km., being on the line connecting Sômachi[1] and Isago.[2]

This island is divided into a number of plateaus, the highest of which is Hyakunodai[3] in the central part of the island, with its greastest elevation of 211 m. near its south edge. Several lower plateaus are arranged in two series of steps on both the east and west sides of Hyakunodai. All these plateaus slope down very gently northwards, their fronts generally merging into the raised coral reefs without any abrupt change in slope.

The raised coral reef, which is the outstanding feature of the island, is an elevated fringing reef by which the island was once entirely surrounded. Its surface, which on the whole is even, is sometimes very irregular, full of pits, furrows, and solution cavities; almost always inclining very



1) Section across Kikai-jima along line A-B in the Geologic Map.

1) 早町, 2) 伊砂, 3) 百之臺.

gently seawards with its outer edge connected directly with the recent fringing reef now growing vigorously below sea level, while its inner edge has been raised up to 20 m. above sea level. It varies much in width from place to place, the average being 500 m. and the maximum 1 km.

Although no large streams are developed on the island, several small ones are found on the north side.

Stratigraphy

Kikai is composed of the following formations, in descending order:

Raised Coral Reefs and Sand Dunes
Kunigami Gravel
Riukiu Limestone
Shimajiri Beds

Shimajiri Beds. These beds, forming the foundation of the island, and exposed along the cliffs and scarps flanking the plateaus, consist mostly of soft, dark, bluish-gray, soapstane-like marls with subordinate fine-grained light-brown sandstanes. A white or gray pumice bed, several meters thick, is found in the upper part of the beds exposed near the top of the slope north of a shrine west of Sômachi. The usually soft marls and sandstones of the beds easily disintegrate when placed in water; the former, if the carbonate of lime is high, sometimes altering into hard marls or impure limestones. No macroscopic fossils have yet been found in these beds although microscopic ones are common, for example, the pelagic foraminiferal tests and remains of Coccolithophoridae and Discoasteridae contained in dark bluish-gray marls. The marls, which are quite homogeneous in texture and greasy to the touch if soaked with water, are comparable to the Blue Mud of the recent semipelagic deposits. Both the light-brown sandstones and the pumice beds are destitute of fossils. The Shimajiri beds are gently inclined in various directions at angles varying from 2° to 20° and cut by numerous faults, some of which do not extend into the overlying Riukiu limestone.

Riukiu Limestone. This unconformably covers the preceding beds on the plateau surface, nearly horizontally or slightly inclined, most of them being 60 m. thick, sometimes hard and cavernous and other times incoherent and granular. Locally they are rich in fossils of various kinds, such as reef-building corals, bryozoa, foraminifera, mollusca, brachiopoda, and calcareous algae; the species varying with locality, an instance being the abundance of *Operculina bartschi* CUSHMAN in that of Shimanaka[1] and *Amphistegina radiata* (FICHTEL and MOLL) in the limestone of Araki.[2] A considerable number of excellently preserved fossils of reef-building and deep-sea corals, bryozoa, gastropoda, lamellibranchiata, pteropoda, brachiopoda; and foraminifera, both large and small were collected from limestone exposed in a white bluff on the roadside on a plateau 500 m. north of Kamikatetsu.[3]

The reef-building corals, according to H. YABE and T. SUGIYAMA (Lit. 42), are

Acanthastrea cf. *hemprichii* (EHRENBERG), *Acropora* sp., *Alveopora* cf. *verrilliana* DANA, *Antillophyllia japonica* (YABE and SUGIYAMA), *Astraeopora* cf. *regalis* BERNARD, *Cyphastrea chalcidicum* KLUNZINGER, *Cyphastrea microphthalma* (LAMARCK), *Euphyllia fimbriata* (SPENGER), *Favia speciosa* (DANA), *Phymastrea valenciennesii* MILNE-EDWARDS and J. HAIME, *Fungia cyclolites* (LAMARCK), var., *Goniastrea pectinata* (EHRENBERG), *Hydnophora exesa* (PALLAS), *Leptoria phrygia* (ELLIS and SOLANDER), *Maeandra* (*Coeloria*) *daedalea* (ELLIS and SOLANDER), *Orbicella curta* (DANA), *Orbicella* sp., *Oulophyllia aspera* QUELCH, *Tubipora rubiola* QUOY and GAIMARD.

The deep-water corals, according to H. YABE and M. EGUCHI (Lit. 46), are

1) 島仲, 2) 荒木, 3) 上嘉鐵.

Caryophyllia compressa YABE and EGUCHI, *C. paucipaliata* YABE and EGUCHI, *Trochocyathus* (*Thecocyathus*) *hanzawai* YABE and EGUCHI, *T.* (*Tropidocyathus*) *intermedius* YABE and EGUCHI, *Citharocyathus venustus* ALCOCK, *Deltocyathus orientalis* DUNCAN, *Peponocyathus orientalis* YABE and EGUCHI, *Discotrochus dentatus* ALCOCK, *Conotrochus elongatus* YABE and EGUCHI, *Heterocyathus aequicostatus* M. EDWARDS and J. HAIME, *Goniocyathus pacificus* YABE and EGUCHI, *Fragilocyathus ?* sp., *Flabellum rubrum* QUOY and GAIMARD, *F. transversale* MOSELEY, *F. stokesi* M. EDW. and H., *F. distinctum* E. EDW. and H., *Parasmilia fecunda* POURTALES, *Antillia duncani* YABE and SUGIYAMA, *Fungia* sp., *Bathyactis kikaiensis* YABE and EGUCHI, *Stephanophyllia* (*Letepsammia*) *formosissima* MOSELEY, *S.* (*L.*) *japonica* YABE and EGUCHI, *S. fungulus* ALCOCK, *Heteropsammia ovalis* SEMPER var. *japonica* YABE and EGUCHI, *Balanophyllia fistula* ALCOCK, *B.* sp., *Endopachys japonicum* YABE and EGUCHI.

The brachiopoda, according to H. YABE (Lit. 49) is

Pictothyris hanzawai YABE.

The molluscs, according to S. NOMURA and N. ZINBÔ (Lit. 51), are

Limopsis multistriata (FORSKÅL), *Limopsis s-kinoshitai* KURODA, *Glycymeris reevei* (MAYOR), *G. pectinata* (LAMARCK), *G. subpectiniformis* NOMURA and ZINBÔ, *G. hanzawai* NOMURA and ZINBÔ, *Arca* (*Arca*) *adamsiana* DUNKER, *A.* (*A.*) *cornea* REEVE, *A.* (*A.*) *kikaizimana* NOMURA and ZINBÔ, *Arca* (*Navicula*) *navicularis* BRUGUIÈRE, *Arca* (*Barbatia*) *fusca* SOLANDER, *A.* (*B.*) *reticulata* GMELIN, *A.* (*B.*) *symmetrica* REEVE, *Arca* (*Bathyarca*) *xenophoricola* (KURODA), *Pseudogrammatodon pacificus* NOMURA and ZINBÔ, *Cucullaea granulosa* (JONAS), *Pteria loveni* (DUNKER), *Vulsella vulsella* (LINNAEUS), *Ostrea imbricata* LAMARCK, *Ostrea musashiana* YOKOYAMA, *Pecten* (*Pecten*) *porphyreus* (GMELIN), *P.* (*P.*) *irregularis* SOWERBY, *P.* (*P.*) *fulvicostatus* ADAMS and REEVE, *Pecten* (*Aequipecten*) *reevei* ADAMS and REEVE, *P.* (*A.*) *vesiculosus* DUNKER, *P.* (*P.*) *spectabilis* REEVE, *P.* (*A.*) *nux* REEVE, *P.* (*A.*) *inaequivalvis* SOWERBY, *P.* (*A.*) *kikaiensis* NOMURA and ZINBÔ, *Pecten* (*Vola*) *sinensis* SOWERBY, *P.* (*V.*) *tricarinatus* ANTON, *Pecten* (*Decadopecten*) *plicus* (LINNAEUS), *Pecten* (*Amusium*) *japonicus* (GMELIN), *P.* (*A.*) *sibogai* (DAUTZENBERG and BAVAY), *Pecten* (*Propeamusium*) *cmadoritinctus* (KURODA), *Spondylus regius* LINNAEUS, *S. nicobaricus* SCHRELBERS, *Plicatula australis* LAMARCK, *Lima* (*Ctenoides*) *oshimensis* SOWERBY, *Lima* (*Limatula*) *japonica* ADAMS, *L.* (*L.*) *bullata* (BORN), *L.* (*L.*) *jacksonensis* THIELE, *Lima* (*Limea*) *limopsis* NOMURA and ZINBÔ, *Septifer excisus* (WIEGMANN), *Trichomya hirsuta* (LAMARCK), *Myodora reeviana* SMITH, *Venericardia millegrana* NOMURA and ZINBÔ, *V. quadriangulata* NOMURA and ZINBÔ, *V.* sp. indet., *Tridacna cumingii* REEVE, *Chama lobata* BRODERIP, *Pseudochama retroversa* (LISCHKE), *Lucina* (*Parvilucina*) *pisidium* DUNKER, *Codakia* (*Jagonia*) *divergens* (PHILIPPI), *Cardium* (*Trachycardium*) *unicolor* SOWERBY, *C.* (*T.*) *infantule* NOMURA and ZINBÔ, *Cardium* (*Laevicardium*) *biradiatum* BRUGUIÈRE, *Cardium* (*Acanthocardia*) *exasperatum* SOWERBY, *Cardium* (*Nemocardium*) *beckei* ADAMS and REEVE, *Cardium* (*Disors*) *lyratum* SOWERBY, *Isocardia* (*Miocardia*) *moltkiana* (LAMARCK), *Dosinia histrio* (GMELIN), *Venus* (*Chione*) *yabei* NOMURA and ZINBÔ, *V.* (*C.*) *foveolata* SOWERBY, *V.* (*C.*) *mindanensis* SMITH, *Venus* (*Callanaites*) *hiraseana* (KURODA), *Gafrarium* (*Circe*) *scriptum* (LINNAEUS), *Pitar* (*Pitarina*) *subpellucida* (SOWERBY), *Tellina* (*Angulus*) *iridella* v. MARTENS, *T.* (*A.*) *kikaizimana* NOMURA and ZINBÔ, *Corbula rotalis* HINDS, *Psammosolen divaricatus* (LISCHKE), *Mactra* (*Spisula*) *asperaeformis* NOMURA and ZINBÔ, *Rocellaris* sp. indet., *Dentalium* (*Laevidentalium*) *corscum* PILSBRY, *Limacina inflata* (D'ORBIGNY), *L. peronii* (LESUEUR), *Clio* (*Clio*) *pyramidata* (LINNAEUS), *Clio* (*Creseis*) *acicula* (RANG), *C.* (*C.*) *virgula* (RANG), *Cuvierina columnella* (RANG), *Cavolina* (*Cavolina*) *longirostris* (LESUEUR), *C.* (*C.*) *globulosa* (RANG), *C.* (*C.*) *tridentata* (FORSKÅL), *C.* (*C.*) *inflexa* (LESUEUR), *Cavolina* (*Diacria*)

trispinosa (LESUEUR), *C.* (*D.*) *quadridentata* (LESUEUR), *Retusa minima* YAMAKAWA, *Cylichna arachis* (QUOY and GAIMARD), *C. totomiensis* (MAKIYAMA), *Bullus vernicosus* (GOULD), *Ringicula caron* HINDS, *Terebra subulata* (LINNAEUS), *T. orthoplicata* NOMURA and ZINBÔ, *T. triseriata* GRAY, *Terebra loebbeckiana* DUNKER, *Conus kikaiensis* PILSBRY, *C. comatosa* PILSBRY, *C. gratacapi* PILSBRY, *C. mucronatus* REEVE, *C. voluminalis* HINDS, *Conus lignarius* REEVE, *Turris* (*Gemmula*) *granosa* (HEBLING), *Daphnella lymneiformis* (KIENER), *Clavus pica* (REEVE), *Cytharella semicarinata* (PILSBRY), *Raphitoma granulidecussata* NOMURA and ZINBÔ, *Cancellaria reeveana* CROSSE, *Ancilla rubiginosa* (SWAINSON), *A. albocallosa* (LISCHKE), *Marginella cotamago* YOKOYAMA, *M. sandwicensis* PEASE, *Vexillum* (*Costellaria*) *fuscoapicatum* (SMITH), *Vexillum* (*C.*) *subtruncatum* (SOWERBY), *V.* (*C.*) *obeliscum* (REEVE), *Latirus* (*Peristernia*) *coreanicus* (SMITH), *Fusinus nicobaricus* (LAMARCK), *F. simplex* (SMITH), *F. pyrulatus* (REEVE), *Siphonalia kikaigashimana* HIRASE, *Nassarius kikaizimanus* NOMURA and ZINBÔ, *N. micans* (A. ADAMS), *Pyrene* (*Columbella*) *liocyma* (PILSBRY), *Mitrella varians* (DUNKER), *Murex sobrinus* ADAMS, *Chicoreus saulii* (SOWERBY), *Latiaxis mawae* (GRAY), *L. deburghiae* (REEVE), *L. tosanus* HIRASE, *Bursa nobilis* (REEVE), *Bursa* (*Bufonaria*)*ranelloides* (REEVE), *Cymatium testudinarium* (ADAMS and REEVE), *C. dunkeri* (LISCHKE), *Distorsio reticulata* (LINK), *Phalium torquatum* (REEVE), *Morum cancellatum* (SOWERBY), *Tonna luteostoma* (KÜSTER), *T.* sp. indet., *Cypraea vitellus* LINNAEUS, *C, fimbriata* GMELIN, *C. helvola* LINNAEUS, *C. caputserpentis* LINNAEUS, *Trivia insecta* (MICHAELS), *T. edgari* SHOW, *T. pilula* (KIENER), *Erato gallinacea* HINDS, *Erato* (*Eratopsis*) *nana* REEVE, *Bittum perpusillum* TRYON, *Royella sinon* (BAYLE), *Triphora solitaria* NOMURA and ZINBÔ, *T. exilis* (DUNKER), *T. granulata* (ADAMS and REEVE), *T. limosa* (JOUSSEAUME), *T. fusca* (DUNKER), *T. concors* (HINDS), *Triphora* (*Inela*) *incisa* (PEASE), *Rissoina* (*Rissolina*) *plicata* A. ADAMS, *R.* (*Zebina*) *affinis* GARRET, *Vermicularia imbricata* (DUNKER), *Siliquaria* (*Agathirses*) *cumingii* MÖRCH, *S. anguina* (LINNAEUS), *Architectonica perspectiva* (LINNAEUS), *A. distinguinda* NOMURA and ZINBÔ, *Heliacus dilectus* (DESHAYES), *Hipponix foliaceus* QUOY and GAIMARD, *Cheilea equestris* (LINNAEUS), *Xenophora pallidula* (REEVE), *Natica alapapilionis* (BOLTEN), *Polinices melanostoma* (GMELIN), *P. flemingiana* (RÉCLUZ), *P. columnaris* (RÉCLUZ), *Astraea* (*Bolma*) *modesta* (REEVE), *Astraea* (*Calcar*) *henica* (WATSON), *Collonista pilula* (DUNKER), *Collonista laeta* (MONTROUZIEUR), *C. globula* (PHILIPPI), *Clanculus clanguloides* (WOOD), *Cantharidus* (*Thalotia*) *japonicus* (A. ADAMS), *Calliostoma ticanonicum* (A. ADAMS), *C. multiliratum* (SOWERBY), *C.* (*Astele*) *kikaianum* NOMURA and ZINBÔ, *Angaria distorta* (LINNAEUS), *A. formosa* (REEVE), *Cyclostrema sulcatum* A. ADAMS, *Liotina discoidea* (REEVE), *L. pseudodiscoidea* NOMURA and ZINBÔ, *Skenea planorboides* YOKOYAMA, *Diodora sieboldii* (REEVE), *Emarginula galericulata* A. ADAMS, *E. crassicostata* SOWERBY, *E. retecosa* A. ADAMS, *E. japonica* A. ADAMS, *E. maculata* A. ADAMS, *Epitonium replicatum* (SOWERBY), *E. azumana* (YOKOYAMA). *Epitonium* (*Cirsotrema*) *suboptimum* NOMURA and ZINBÔ, *Eglisis tricarinata* A. ADAMS and REEVE, *Melanella thaanumi* PILSBRY, *Turbonilla* (*Careliopsis*) sp. indet.

The large foraminifera are

Alveolinella quoyi D'ORBIGNY	common
Amphistegina radiata (FICHTEL and MOLL)	common
Baculogypsinoides spinosus YABE and HANZAWA	common
Carpenteria proteiformis GOËS	rare
Cycloclypeus gümbelianus BRADY	not rare
Heterostegina depressa D'ORBIGNY	common

Homotrema rubrum LAMARCK . . . . . common
Marginopora vertebralis QUOY and GAIMARD . . . . . common
Miniacina miniacea (PALLAS) . . . . . common
Sporadotrema cylindricum CARTER . . . . . not rare

Only megalospheric specimens of *Cycloclypeus* are found in the loose calcareous sand from this locality. A great number of the microspheric forms with a few megalospheric forms of the same species are found together with a considerable number of *Operculina bartschi* CUSHMAN in the Riukiu limestone of Shimajiri in the middle part of the island.

Kunigami Gravel. The plateaus are almost entirely built up of Riukiu limestone in the upper part, the same being usually covered with residual clay or soil, while a gravel bed occasionally tops the plateau surface as in the east of Suitengû-yama[1] sand dune. The gravel bed consists of small rounded boulders of Riukiu limestone intermixed with loose calcareous sands. The plateau surface, even where it is not covered by the gravel bed being sometimes oblique to the bedding plane of the Riukiu limestone, is believed to be an abrasion plane.

Raised Coral Reefs. These reefs, which entirely surround the island, are composed almost entirely of reef-building corals and remains of other reef organisms, such as foraminifera, bryozoa, mollusca, etc. Cemented into hard limestones or still left unconsolidated in a loose and incoherent condition, the reef corals of the raised coral reefs are usually much better preserved than those in the Riukiu limestones. The dominant foraminifera in the raised coral reefs are *Calcarina spengleri* LINNÉ and *Baculogypsina sphaerulata* (PARKER and JONES), while *Cycloclypeus* and *Baculogypsinoides*, so abundant in the Riukiu limestone, are absent in them. The raised coral reefs and the Riukiu limestone are easily distinguished from each other by differences in their textures and organic contents, even though the two may be found side by side.

Sand Dunes. These sand dunes, composed mainly of foraminifera sand, are extensively developed as low hills at Suitengû-yama, as also west of Shidooki,[2] and north of Sateku,[3] and near Tobiyo-zaki. The dune sand, which occasionally displays cross-bedding and is consolidated to a more or less coherent rock, usually contains abundant shells of land snails (mostly *Euhadra* sp.), and also foraminifera ; the predominant species of the latter being much the same as those in the raised coral reefs and in the recent shore sands. These dunes, in their occurrence as well as in their fossil contents, seem to indicate contemporaneity with the raised coral reefs just described.

Tectonic Structure.

As already stated, the Shimajiri beds, which are traversed by faults of various trends and dips in varying directions at small angles, is unconformably overlain by the Riukiu limestone, which is nearly horizontal or inclined northwards at small angles, In places, the Kunigami gravel covers the wavy surface of the Riukiu limestone.

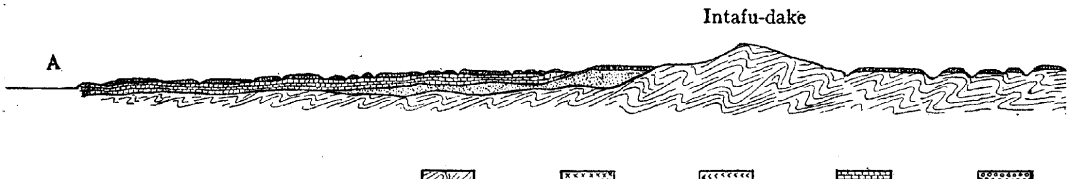
Kikai, which is traversed by younger tectonic lines of N.—S. and N. E.—S. W. trends, presents on the whole a horst structure. That is to say, the bulwark-like scarp that faces west and stretches from Urabaru[4] to Gusuku[5] beyond Kawamine[6] and Yamada[7] in a north and south direction, is a remarkable fault scarp, in that its upper part is a vertical cliff of Riukiu limestone, while its lower part displays a steep skirt of Shimajiri beds. A similar topography, exhibiting the lighological characteristics of two different sedimentary beds, may be seen along a line drawn from Keraji[8] to Isago, beyond Takikawa,[9] and from Kamikatetsu to Sômachi along the southeast coast.

1) 水天宮山, 2) 志戸桶, 3) 佐手久, 4) 浦原, 5) 城, 6) 川嶺, 7) 山田, 8) 花良治, 9) 瀧川.

After the dislocation of the Riukiu limestone and the Kunigami gravels by late tectonic disturbances, the strand line shifted positively, while the fringing reefs that were built around the island were recently elevated 20 m. by a negative shift of sea level.

Toku-no-shima.

Geographical Situation and Topographical Features.



2) Section across Toku-no-shima along

Toku lies 24 km. southwest of Yoro, one of the dependent islets of Amami, in Lat. 27°39′—27°54′ N. and Long. 128°52′—129°02.5′ E. Its longer axis, from Tete[1] to Isen-zaki,[2] 25.3 km, has a N.—S. trend. The maximum and minimum widths in an east and west direction are from Kanninzaki to Intafu-zaki[3] and San[4] to Matsubaru,[5] respectively ; the former being 16 km. and the latter 6 km.

In the northern part is a group of steep-sided mountains extending nearly east and west ; the highest of them Ameki-dake,[6] being 533 m. South of the former, rise prominently another group of steep-sided mountains, namely, Sansontsuji-dake[7] (496 m.) Ôgusuku-yama[8] (331 m.), and Umanokura-dake[9] (210 m.). The other mountains, Yamatogusuku-dake[10] (249 m.), Minata-dake[11] (437.7 m.) Inokawa-dake[12] (644 m.), Hagi-dake[13] (282.3 m.) and Tanpatsu-yama[14] (447 m.) form a group in the middle part of the island, aligned N. W.—S. E., and with steep sides like those of the mountains in the northern part of the island. Intafu-dake[15] (417.4 m.), somewhat isolated from the Inokawa-dake group and others, however, has a very gentle slope. All the mountain masses just mentioned are surrounded by successive coastal terraces of wide extent, and their slopes, in contrast to those of Amami, never descend straight into the sea. The mountain groups in the northern part of the island are separated from those in the middle by a broad trough that extends E.—W. from Ketoku[16] to Asama,[17] Intafu-dake is separated from Hagi-dake by a dissected terrace 200 m. above the sea. The terraces vary in width according to place, being broadest on the south coast reaching 7.6 km. and narrowest on the north and east coasts, where they are 1.5 km. The average altitudes of the successive terraces are

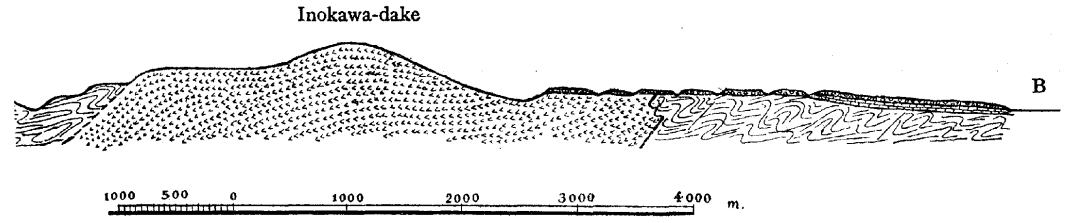
20 m., 40 m., 60 m., 100 m., and 300 m. on the south coast,
40 m., 100 m., and 200 m. on the west coast,
40 m., 60 m., and 100 m. on the east coast.

The highest terrace is everywhere the most extensive ; and flanked behind by a mountain, the change from mountain slope to surface slope of the terrace is abrupt. Generally, the terraces uniformly bevel the Riukiu limestone, Palaeozoic and granitic rocks that have intruded into the Palaeozoics. Narrow abrasion benches, 2—5 m. above the sea and of an average width of 100 m., cut along the shore. Their surfaces, which are generally quite bare without any deposits, are often covered with a veneer of coralline limestone. These benches are always found along shores of Palaeozoic and intrusive rocks, whereas, in regions where the Riukiu limestone is exposed along the shore, instead of the raised abrasion benches deep gouges have deen formed by wave action. The

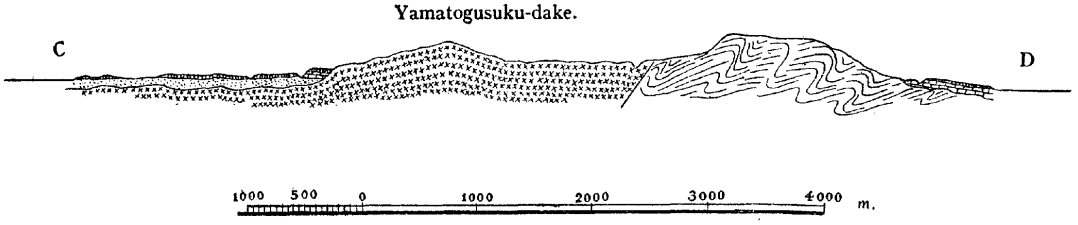
1) 手々, 2) 伊仙崎, 3) 犬田布崎, 4) 山, 5) 松原, 6) 天城岳, 7) 三方通岳, 8) 大城山, 9) 馬ノ鞍岳, 10) 大和城岳, 11) 美名田岳, 12) 井ノ川岳, 13) 剣岳, 14) 丹發山, 15) 犬田布岳, 16) 花徳, 17) 浅間.

raised benches correspond to the raised coral reefs of Kikai and Kume.

Since the mountainous region of the middle part of this island lies near its eastern side, the large rivers flow westward and empty in the Tung-hai. The largest of these rivers is the Akirigami,[1] with the Kanokawa[2] next in size, both deeply incising the high level terraces as dendritic courses. The smaller streams that also cut into the high level terraces are fed only by heavy rains. The higher level terraces are more deeply dissected.



line A—B in the Geologic Map.



2') Section across Toku-no-shima along line C—D in the Geologic Map,

Stratigraphy.

Toku is composed of the following formations, in descending order :

Sand Dunes
Kunigami Gravel
Riukiu Limestone
Palaeozoic Formation

Palaeozoic Formation. This consists mostly of slates with subordinate sandstones. It is intruded by masses of granite (adamellite) and diabase. The contact rocks, such as spotted slate and hornfels, which are found in a number of places, e. g., north of Ketoku, Shimokushi[3], south of San, etc., are also occasionally found at places lying far from the contact zone, while on the other hand non-metamorphosed slates are sometimes found near the granitic masses. The Palaeozoic formation is intensely folded and sheared by numerous thrusts ; its strike, regular as a rule, being either N.—S. or N. E.—S. W., while the dip is almost always westwards, although at different angles. There are some spotted slates remetamorphosed by later dynamic action. The lithological character and the structure of the Palaeozoic formation force us to the conclusion that its intense deformation occurred after the granitic intrusion.

Riukiu Limestone. In this island (Toku) the Shimajiri beds and the other Tertiary rocks are absent, while the Palaeozoic formation is directly overlain by the Riukiu limestone, which is subdivided into upper and lower. The lower Riukiu limestone, 60 m. thick and which is an arenaceous

1) 神利. 2) 鹿ノ川. 3) 下久志.

facies unknown in the other islands of the Riukiu group, consists of soft white and light brown sandstones and conglomerates or gravels formed of pebbles of Palaeozoic and intrusive rocks. Unfossiliferous except the uppermost part, they pass upwards more or less abruptly, exhibiting the normal facies of the Riukiu limestone without any stratigraphical breaks. The upper limy facies of the Riukiu limestone vary in lithological character and organic contents. That is to say, it is sometimes hard and cavernous and other times loose and granular; and whereas foraminifera *Operculina bartschi* CUSHMAN and *Cycloclypeus carpenteri* BRADY are abundant in it near Kamezu, Kametoku[1], and Orochiguchi,[2] reef corals predominate near Nishiakina[3] and Itokina,[4] and *Lithothamnium* near Ueomonawa[5] and Hedono.[6] The thickness of the upper part at the mouths of the Akirigami River and Kanokawa River is 100 m.

Kunigami Gravel. This rests on the rocks just mentioned covering the surface of the high successive coastal terraces. It is a few meters thick and consists of reddish soils and pebbles of slates and sandstones of Palaeozoic formation and granitic rocks derived from the mountains behind the terraces and their foundations.

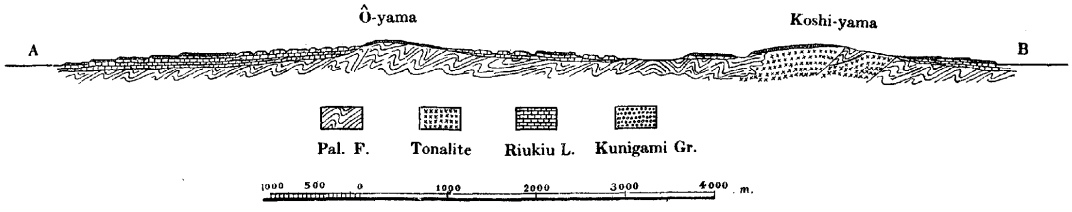
Okierabu-jima.

Geographical Situation and Topographical Features.

The island of Okierabu, also called Okinoerabu, is situated 34 km. southwest of Toku in Lat. 27°26′—27°19′ N. and Long. 128°31′—128°43′ E. Roughly triangular in outline, its longer axis of 20 km., lies nearly northeast and southwest. From a maximum width of 9.5 km. on its southwestern part, it tapers towards Kunigami-zaki, its northeastern tip.

The island is on the whole low and flat. Ô-yama,[7] the greatest elevation in the island and situated in the middle of its southwestern part, is a broad flat-topped hill 245.9 m. high. Around the broad and flat summit of Ô-yama, are a series of dissected terraces of 220 m., 180 m., 100 m., 60 m., 40 m., and 20 m. in elevation, concentrically arranged. Countless small dolines are developed on the surfaces of these terraces, of which those that are shallow and flat-bottomed are frequently utilized as either rice or sweet potato fields. Koshi-yama,[8] the next high flat-topped hill, situated in the middle of the northeastern part of the island, is 188.6 m. in height. This hill is also surrounded by a series of dissected terraces, 140 m., 100 m., 60 m., 30 m., and 20 m. in elevation. Similar terraces are also found in the northeastern arm of the island. The cliff-type coast of this island is everywhere bounded by precipices, sometimes as high as 100 m.

Ô-yama being situated in the middle of the broad southwestern part of the island, a radial valley system is developed there, in which most of the streams flow only during times of heavy rain. Some underground drainage in the limestone districts around Ô-yama as well as around Koshi-yama may be observed in the limestone caves near the coasts. The Amata,[9] the largest stream in the island, runs between Ô-yama and Koshi-yama and empties in the Pacific at a village of the same name as the stream. The northeastern part of the island northeast of Wadomari[10] has no streams.



3) Section across Okierabu-jima along line A—B in the Geologic Map.

1) 鷲徳, 2) 卸口, 3) 西阿木名, 4) 糸木名, 5) 上面縄, 6) 邊土野, 7) 大山, 8) 越山, 9) 餘多, 10) 和泊.

Stratigraphy.

Okierabu consists of the following formation, in descending order :

Raised Beach Deposits
Kunigami Gravel
Riukiu Limestone
Palaeozoic Formation

Palaeozoic Formation. This formation, composed chiefly of slates, with subordinate sandstones, is exposed near the summits of Ô-yama and Koshi-yama, Uchishiro,[1] etc. Near Uchishiro and south of Koshi-yama, these rocks are contact-metamorphosed into spotted slates and hornfelses. Besides, a thin band of schalstein is found interbedded in the slates and sandstones in a road-cutting southwest of Koshi-yama. The strata, contorted and sheared by normal and reverse faults, strikes generally with a N. E.—S. W. trend and with a westward dip at various angles.

Near Uchishiro and the top of Koshi-yama, masses of tonalite crop out in contact with the Palaeozoic rocks. They are however almost entirely decomposed into medium grained sand, so that they look like a massive sandstone, intricately dissected by numerous deep gorges with the appearance of a badland topography, Small outcrops of tonalite and porphyrite are found also near Deki[2] and Kunigami.[3]

Riukiu Limestone. As the Shimajiri beds and the other older rocks are absent in this island, Riukiu limestone directly covers the erosion surface of the preceding formation, either horizontally or slightly inclined seawards. The Riukiu limestone, which is usually massive and often stratified, is mostly compact and hard, but frequently loose and granular, white or light-yellow, and 100 m. thick at the most. It is composed of foraminifera in great quantities, but rather few reef-building corals. Near Shimajiri[4] and in a road-cutting 500 m. north of Kogome,[5] well preserved specimens of large sized *Cycloclypeus carpenteri* BRADY are found in great profusion.

Kunigami Gravels. These gravels cover the surface of the high level terraces, not excepted, the summits of Ô-yama and Koshi-yama. They consist mostly of reddish soils and boulders and pebbles of Palaeozoic and igneous rocks, with occasionally those of Riukiu limestone, and of fine grained massive sand, as exposed in road-cuttings at Inobe[6] and south of Nishibaru.[7]

The gravels and sands, which usually lie horizontally, are often tilted in various directions at an angle of 20°, as seen near a pond north of Tetechina.[8]

Raised Beach Deposits. Since the Riukiu limestone forms vertical sea cliffs almost completely around the coast of the island, raised benches or beaches, except in a few places, are scarcely developed. The few that are found are north of Kunigami-zaki, northeast of Wadomari, west of Inobe, and southwest of Ôtsukan.[9] The raised beaches are generally narrow and sometimes covered with calcareous sands that frequently consolidate into hard limestones.

The Okinawa Group.

Okinawa-jima and Its Dependent Islets.

Geographical Situation and Topographical Features.

Okinawa, the largest of the Riukiu Islands, lies in Lat. 26°52.3′—26°0.2′ N. and Long. 127°38′—128°20′ E. Topographically it is divisible into three parts, the northern, middle, and southern. The northern division comprises the area that lies north of the isthmus, between Ishikawa[10] in Nagakami-

1) 內城, 2) 出花, 3) 國頭, 4) 島尻, 5) 小米, 6) 伊延, 7) 西原, 8) 手々知名, 9) 大津勘, 10) 石川.

gun and Nakadomari[1] in Kunigami-gun ; the middle, the area that lies between the isthmus and a line drawn between Naha and Yonabaru[2] ; the southern, that part that lies south of a line drawn between Naha and Yonabaru. These three topographical divisions almost coincide with the three political divisions, namely the northern division almost belonging to Kunigami-gun ; the middle to Nakagami-gun, and the southern to Shimajiri-gun.

The Northern Division. The northern division, 67 km. long, and elongated nearly N. E. —S. W., is broadest (15 km.) between Aha[3] and Akamaruzaki[4] and narrowest (4 km.) at the isthmus of Ishikawa. Projecting westward from its middle part is the subquadrangular Motobu Peninsula, which is 13 km. wide from east to west and 12 km. from north to south. It is connected with the main part of the island merely by an isthmus between Nago and Nakôshi.[5] Kouri, Yagaji, and Wô are small islets on the east side of the peninsula, while Sesoko, Ie, and Minna are on its west. A high steep-sided median ridge, which extends throughout the whole length of the northern division, is discontinuous at places, being interrupted by lowlands. This ridge has high peaks, such as Irime-dake[6] (420 m.), Ibu-dake[7] (354 m.), Iyû-dake[8] (450 m.), Ubashi-dake (300 m.), Têchi-dake[9] (295 m.), Kushi-dake[10] (335 m.), Ishi-dake[11] (262 m.), Onna-dake[12] (363 m.), and Ishikawa-dake[13] (220 m.). Extensive coastal terraces are developed along both the east and west sides of the backbone ridge.

The west coast of the northern division has very few embayments, whereas the east coast has many, the important ones being Taira-wan (bay),[14] Arume-wan,[15] Teniya-wan,[16] Ôura-wan,[17] wan,[18] Kanna-wan,[19] and Kin-wan.[20]

At Hedo-zaki, the northern end of the island, two terraces may be distinguished, the one 100 m. and the other 200 m. in elevation, the two being separated by an escarpment. The east coast of the northern division between Oku[21] and Taira[22] has a well developed 200 m. terrace ; very extensive, with a maximum width of 8 km. near Niikawa[23] and generally ending in precipitous cliffs, 140—160 m. high. The coast from Ada[24] to Akazaki,[25] on the other hand, is flanked by a narrow 100 m. terrace. The west coast has also a broad terrace, 200 m. above the sea, extending along the foot of the backbone ridge symmetrically to that of the east coast, and terminating in steep cliffs 180 m. in height.

A 100 m. terrace forms a watershed between Taira and Shiwoya,[26] where the backbone ridge is interrupted by a transverse valley. In the basin of Taira, a dissected terrace, 80—100 m. high, is widely developed.

Along both the east and west sides of the mountain forming the backbone between the embayments of Taira-wan and Arume-wan, 200 m. terraces are developed ; that on the west side being limited seawards by sea cliffs 100 m. high and that on the east side, 4 km. wide, bordered by another low terrace, 80—100m. high and 2 km. wide, which drops into the sea as cliffs 20 m. high.

Both sides of this mountain backbone between Arume-wan and Teniya-wan are flanked by a 200 m. terrace, the western one of which descends to sea cliffs 100 m. high, while the eastern one, 6 km. wide, is bordered by another terrace 1 km. broad. and 100 m. above sea level.

In the stretch between Teniya-wan and Ôura-wan, Têchi-dake is bordered on both sides by an extensive 200 m. terrace ; the western one dropping either to the sea or to the Nakôshi lowland by steep escarpments 100—200 m. high. The extensive eastern terrace, which is 6 km. wide, drops into the sea as steep sea cliffs 140 m. high between Teniya and Kayô,[27] while it is flanked by another low terrace 100 m. high between Kayô and Abu,[28] the lower terrace having a sea cliff 20 m. high at

1) 仲泊, 2) 與那原, 3) 安波, 4) 赤丸崎, 5) 仲尾次, 6) 西銘岳, 7) 伊部岳, 8) 伊湯岳, 9) 一岳, 10) 久志岳, 11) 石岳, 12) 恩納岳, 13) 石川岳, 14) 平良灣, 15) 有銘灣, 16) 天仁屋灣, 17) 大浦灣, 18) 久志灣, 19) 漢那灣, 20) 金武灣, 21) 奥, 22) 平良, 23) 新川, 24) 安田, 25) 赤崎, 26) 鹽屋, 27) 嘉陽, 28) 安部.

its end.

In the southern part of the northern division that extends from the isthmus between Nago and Ôura to the same between Ishikawa and Nakadomari, the mountain backbone is directly bordered by 100 m. terraces on both the east and west sides, except for certain small areas where they are intervened by a 200 m. terrace. The average width of the 100 m. terrace is 1 km. on the Tunghai side and 5 km. on the Pacific side, where it ends in sea cliffs 20 m. high. It traverses the backbone range at the isthmus of Ishikawa and also along a transverse valley between Afuso[1] and Kin.[2] It is likely that Mt. Yuntanza[3] (220 m)., in the northern part of the middle division of the island, is a continuation of the backbone range in the northern division.

The heights of the terraces in the northern division on the opposite sides of major embayments, differ considerably, while the backbone mountain as well as the Palaeozoic formation show certain deviations in their strike from their respective general trends near the embayments. These facts suggest the presence of younger tectonic lines traversing the island along the embayments.

Although the coastal line north of Shiwoya on the west side of the northern division runs linearly in a N. E.—S. W. direction, the monotony is broken by a short projection of Akamaru-zaki west of Hentona. This triangular promontory is a sand bank, a meter or more high, enclosing small flat-topped hills 30 m. high and containing a small lagoon called Kaganshi[4] (signifying water-mirror). The hills are built of nearly horizontal beds of sand and gravel. In two of them, both only a few meters high, one of which lies at the tip of Akamaru-zaki and the other to the east of Tôbaru,[5] sands and gravels of young geological formation are unconformably underlain by a Palaeozoic crystalline limestone.

The Motobu Peninsula. This peninsula, which is largely mountainous, is divided into two mountainous tracts, the northern and southern, by a valley running from Toguchi[6] to Katena[7] in an east and west direction. These two mountainous tracts are built of the same Palaeozoic formation that forms the mountain ridges running N. E.—S. W. The highest peaks are Yae-dake[8] (457 m.) and Katsuu-dake[9] (451 m.) in the southern tract and Otoha-dake[10] (300 m.) in the northern.

Successive coastal terraces are well developed on the north, east, and south sides of the peninsula, the highest of which is 100 m. and 700 m. wide, the middle 40 m. high and lowest, being discontinuous, 20 m. above the sea. The total widths of the terraces vary with place, being 3 km. at Jahana[11] and Bise,[12] 1.3 km. near Gushiken,[13] 2.6 km. near Nakasone,[14] and 1.5 km. along the east coast near Wakugawa.[15] Where the 100 m. terrace cuts the Palaeozoic limestone, dolines are common on its surface, a number of them being also found here and there on the middle and lowest terraces, cutting the Riukiu limestone. Although there is a terrace 100 m. high and 1 km. wide between Toguchi and Sugâ[16] beyond Sakimotobu,[17] on the west coast of the southern half of the peninsula, the mountains on its south drop steeply into the sea. Further south, the coast is terraced; the highest terrace extends from Furukatsuo[18] to the north of Goga[19] and is 170 m. (maximum) with its surface sloping down very gently southwards until it comes to a high sea cliff (100 m.) above a narrow raised beach. Viewed from a distance, this terraced land has the appearance of a tilted block. Between the southern border of this high terrace and the Nago and Nakôshi line, is a broad dissected terrace, 30—40 m. high, flanked in its front by another broad flat lowland, a raised beach.

Kouri is a terraced island subquadrangular in outline. The central part of the islet, which is a 100 m. terrace, is surrounded by two or three successive terraces parallel to the coast. These terraces continue to those of the Motobu Peninsula just mentioned.

1) 安富祖, 2) 金武, 3) 讀谷山, 4) 鏡水, 5) 桃原, 6) 渡久地, 7) 嘉手納, 8) 八重岳, 9) 嘉津宇岳, 10, 乙羽岳, 11) 射花, 12) 蒲瀬, 13) 具志堅, 14) 仲宗根, 15) 湧川, 16) 鹽川, 17) 崎本部, 18) 古嘉津尾, 19) 臭我.

Yagaji is a flat-topped island lying east of the Motobu Peninsula, from which it is separated by a narrow strait only 150 m. wide. Its even surface is probably continuous with the terrace on the east coast of the peninsula.

Sesoko is separated from the peninsula by a narrow strait 400 m. wide. The highest part of the islet, which is flat and 70 m. above the sea, is surrounded by precipitous limestone cliffs, excepting at certain places where a 40 m. terrace is developed.

Minna is a very low small islet, at most 10 m. high, and about 3 km. west of Sesoko. It is of horseshoe shape with a lagoon inside, and composed of calcareous raised beach deposits.

Ie is a comparatively large islet situated 5 km. west of Bise-zaki, the northwestern end of the Motobu Peninsula. It extends from east to west, measuring 8.5 km. and 4 km. from north to south. A flat-topped island, composed mostly of Riukiu limestones, with a sharp pinnacle 170 m. high called Gusuku[1] (signifying castle) on its highest flat surface, lies 2 km. distant from both the north and east coasts. This island, which is probably continuous with the 80 m. terrace of Bise, Motobu Peninsula, is surrounded by a narrow low terrace 40 m. above the sea. The northern coasts are of cliff-type, while the remaining coasts are flanked by raised abrasion benches a few meters above the sea. The Gusuku is built up of Palaeozoic radiolarian chert.

The Middle Division. The middle division, which is elongated almost N.—S. for 26 km., is broadest in its northernmost part, being 17 km. wide between Zanpa-misaki and Tengan,[2] whence it tapers southwards to a width of 6 km. The tongue-like peninsula of Yoshô[3] that projects southeastwards from the northernmost part of the middle division is 8 km. long and 3 km. wide. Along the east side of the middle division, the small islets, Kudaka, Tsuken, Hamahiga, Henza, etc., are aligned from north to south.

Whereas the northern division carries the backbone ridge, both the middle and the southern division on the whole are either hilly country or dissected plateaus. Only Mt. Yuntanza, in the northern part of the middle division, remains as an erosion relic of the backbone ridge, which extends N.—S. and is built up mainly of Palaeozoic rocks. The two hills 120 m. high, and lying west of Maeda[4] to the north of Zamami[5], are separated from Mt. Yuntanza by a highly dissected terrace 80 m. above sea level.

To the west of Zamami, from Zanpa-misaki to Katena,[6] we find developed a flat terrace 80 m. high, the surface of which is hollowed out by some dolines, the foundation being Riukiu limestone, although it is covered with sands and gravels. To the east and south of Mt. Yuntanza are the broad, dissected table-lands or plateaus of Misato-,[7] Gushikawa-,[8] Goeku-,[9] Yuntanza-, and Chatan-mura.[10] Many limestone pinnacles rise from the general level of the surface of the plateau, which is built of Riukiu limestone and covered with the Kunigami gravel.

The Yoshô Peninsula. This peninsula on the whole is believed to be a tilted block. Its southwest coast is cliffy and straight throughout, with its surface sloping down gently northeastwards to the sand beach on the northeast coast, which also is almost straight. The seaward edge of the gentle slope is bordered in places by low escarpments.

From the west end of the Yoshô Peninsula to Yonabaru is a broad raised beach descending gently to the sea. It is 10 m. or slightly higher at its inner margin and 0.5—2 km. wide. Two tongue-shaped sand bars, one at Awase (Ôse)[11] and the other a little south of it, project eastwards from the coast. The inner margin of the raised beach is bounded by the high cliff or steep slope of the western border of the plateau in the middle division of the island. This plateau, with its surface sloping very gently westward, and averaging 150 m. high at its highest parts, has a wide terrace in

1) 城, 2) 天願, 3) 與勝, 4) 眞榮田, 5) 座間味, 6) 嘉手納, 7) 美里, 8) 具志川, 9) 越來, 10) 北谷, 11) 泡瀬,

its western front, 1 km. wide and 80 m. high, bounded by an escarpment where it descends to a broad sand beach on the west coast just as in the case of the east coast. The country both east and west of the city of Shuri[1] is one of rolling hills, with erosion remnants of the Riukiu limestone at the tops of many of the prominences.

The nine small islets in a N.—S. alignment east of Kin-wan and Nakagusuku-wan[2] of Okinawa enumerating from the northernmost one are

Ike (Ichi) -banare. A low and flat island entirely built of Riukiu limestone, at most 40 m. high.

Taka (Miyagusuku) -banare. A flat limestone plateau of Riukiu limestone, 120 m. high, with a low and deeply dissected terrace, 60 m. high in its eastern part, and lying south of the village of Miyagusuku.

Henza-banare. A tilted block of Riukiu limestone, with its general surface dipping gently northeastward. Its southwest coast is bounded by a high limestone cliff, 115 m. in height.

Hamahiga-banare. An islet consisting of three tilted blocks of Riukiu limestone and with a complicated topography as befits its structure.

Yabuji-banare. A tilted block of Riukiu limestone with a southwestward dip; its northeast coast being a limestone cliff 40 m. high.

Ukibaru- and Minami(Fê)-ukibaru-banare. Two low, flat islets, 12 m. and 4 m. high respectively, and built up of raised coral reefs.

Tsuken- and Kudaka-jima. Two low and flat islets, 40 m. and 17 m. in maximum heights respectively; built up almost entirely of Riukiu limestone and covered with light yellow calcareous dune sand.

The Southern Divsion. The southern division, which is triangular in outline, has its greatest width north, between Sakibaru-zaki[3] and Chinen-zaki,[4] where it is 20 km. wide, whence it tapers southwards to Kyan-zaki, the southern extremity of the island. The southern division, on the whole, is hilly country, and in its southern area, where dissection has not proceeded so far as elsewhere are extensive limestone plateaus, Yoza-dake[5] (167 m.), Yaeju-dake[6] (155 m.), and two other, unnamed plateaus, one of which extends from Itokazu[7] to Tamagusuku (200 m.) and the other from Kakinohana[8] to Kuteken[9] (167 m.); these latter plateau being more extensive. These plateaus consist of Riukiu limestone, either horizontal or slightly inclined in various directions, and underlain by the Shimajiri beds. They are almost invariably surrounded by precipitous limestone cliffs, although their tops are almost flat and covered either with a residual clay or with Kunigami gravel. Where the Riukiu limestone has been completely removed by denudation the land is reduced to rolling hills built up of the Shimajiri beds alone, although its erosion remnants are found capping the tops of some of the hills that are composed of the Shimajiri beds. Except in the southernmost coast, where the Riukiu limestone forming the sea cliffs are directly exposed to marine abrasion, the hilly country plateaus are surrounded by a raised beach. Coastal sand dunes of calcareous sand (foraminifera, fragments of reef-building corals, etc.) are found at Odo.[10]

Okinawa, being on the whole a narrow island, with elevations in its middle part, either as backbone ridges or plateaus, and there being no important longitudinal tectonic lines, has no marked longitudinal valleys; all the rivers being short and flowing either eastwards to the Pacific or westwards to the Tung-hai.

Stratigraphy

Okinawa-jima and its dependent islets consist of the following formations, in descending order:

1) 首里. 2) 中城灣. 3) 先原崎. 4) 知念崎. 5) 與座岳. 6) 八重洲岳. 7) 糸數. 8) 垣花. 9) 久手堅. 10) 小渡.

Raised Beach Deposits
Kunigami Gravel
Riukiu limestone
Shimajiri Beds
Palaeozoic Formation

Palaeozoic Formation : Mt. Yuntanza in Nakagami-gun, as well as the mountains and the foundations of the high level terraces in Kunigami-gun and those of the dependent islets (Ie, Sesoko, Kouri, and Yagaji) are of Palaeozoic formation, composed mostly of slates and sandstones with occasional intercalations of radiolarian cherts, crystalline limestone, and conglomerates. Though the formation is intensely folded, contorted, overthrusted and sheared, its general strike is rather constant, being N. E.—S. W. and therefore parallel to the length of the northern division of the island, usually with westward dip at various angles. Sometimes the slates are altered into graphite schists and the sandstones into chlorite schists. The conglomerates exposed on the east coast of the island near Arume, Kawada, and Sedake,[1] and which are interbedded in the slates and sandstones, contain round pebbles of sandstones, slates, and granite. Of these pebbles, the kind that consists of slates and granitic rocks differ entirely, so far as we know, from those exposed in the Riukiu Islands, while the other kind is indistinguishable from the Palaeozoic slates just mentioned, being as a rule angular or subangular, probably a product of contemporaneous erosion.

The limestone occurs interbedded in a series of slates, sandstones, and cherts in the Motobu Peninsula and elsewhere along the west coast. They are almost crystalline, usually bare of fossils as are the other rocks of the same formation, and generally white or gray, but occasionally green where they are rich in an argillaceous matter now altered to chloritic substances. As an extremely rare case, *Neoschwagerina*, *Verbeekina*, *Palaeofusulina* (=*Pseudofusulina*), and some other smaller foraminifera characteristic of the Permian were detected in a semi-crystalline part of the marble exposed near Tamagusuku in the Motobu Peninsula (Lit. 50). Although the stratigraphical position of the limestones is not exactly known, seeing that they are always found on the west side of the island and that the Palaeozoic formation in general has a westward dip, they probably occupy the higher horizons in the Palaeozoic formation.

The Palaeozoic formation is intruded by porphyrite west of Nakama,[2] at the Todoroki[3] waterfall southeast of Sukuta,[4] at Tsuha,[5] near Mitsutsumi,[6] etc.

Shimajiri Beds. Mainly composed of soft bluish-gray marls with subordinate soft light-brown sandstones and gravels, and constituting the foundation of the middle and the southern division as well as of the dependent islets lying east of the island, these beds occupy also an isolated area near Nakôshi, Kunigami-gun, besides forming the foundation of a 170 m. terrace in the southern half of the Motobu Peninsula as seen exposed at Wô-jima near Nakôshi. Most of the Shimajiri rocks are soft, easily distintegrating when placed in water, and containing numerous well preserved fossils. While most of the Shimajiri rocks are very rich in organic remains of microscopic size, such as foraminifera (mostly pelagic), Coccolithophoridae, sponge spicules, etc., a Shimajiri marl exposed at Nakôshi contains well preserved lamellibranchiata and gastropoda in addition to abundant remains of foraminifera.

The Shimajiri beds in Okinawa-jima, except near Shuri, where it is distinctly folded, is everywhere tilted in various directions at small angles.

Riukiu Limestone. The higher parts of the hilly country, plateaus, and coastal terraces in Nakagami- and Shimajiri-gun are formed of Riukiu limestone. In Kunigami-gun, its distribution is more or less restricted to the Motobu Peninsula, near Nakadomari, Onna, and Afuso on the western

1) 瀬高, 2) 仲間, 3) 轟, 4) 数久田, 5) 津波, 6) 三堤.

side, the islets off both the west and east coasts ; and near Abu-zaki, Kanna, and Kin on the eastern side.

This limestone is a stratified formation composed of various limestones, mostly white to light-yellow, some of them cavernous and other unconsolidated, being merely incoherent granular calcareous sands. Although fossils are common, the commonest types being calcareous algae, foraminifera, reef-building corals, mollusca, and other lime secreting organisms, reef-building corals are comparatively rare. The formation, which occasionally has many well rounded pebbles of Palaeozoic rocks in its basal part, is often conglomeratic; for example, near Goga, Sesoko, and Katena. Near Sûgenji[1] temple in the suburb of Naha, the basal part contains round water-worn pebbles of its own limestones. Where the Riukiu limestone rests on the Shimajiri beds it is generally not conglomeratic in the basal part, but instead, a compact limestone free from exogenous blocks of Palaeozoic and of the Shimajiri beds directly covering the soft marls of the Shimajiri beds. The thickness of Riukiu limestone in Okinawa is 40 m.

Kunigami Gravel. This is a series of gravels, sands, and lateritic soils typically developed on the 80—100 m. terraces of the northern and middle divisions, lying on abraded surfaces of both Palaeozoic rocks and Riukiu limestone. Occasionally some layers of bluish-gray sand and clay are interbedded in the gravel bed in places, for example, along the slope from Yenohi[2] to Higaonna[3] in Nakagami-gun and along the pass from Shiwoya to Taira. The pebbles in the gravel beds are hard well rounded Palaeozoic rocks. The Kunigami gravel sometimes a ttains to a thickness of 20 m., but is usually 5 m. or less, and completely bare of fossils.

Raised Beach Deposits. All along the base of the sea cliffs in Kunigami-gun, a narrow raised abrasion bench, 5 m. or slightly more in height, has been cut, beveling either the Palaeozoic formation or the Shimajiri beds. Occasionally a veneer of firmly cemented calcareous deposit, composed of corals, foraminifera, other reef organisms is found on the raised abrasion bench, the calcareous deposit being quite similar to that found in Amami. Although the broad raised beaches developed in the middle and the southern division are composed almost of non-calcareous sand, this calcareous raised beach deposit is also sometimes found on the coasts of these two divisions. Minna, Ukibaru, Minami (Fê)-ukibaru and the three islets of Kê are formed of this calcareous deposit. In the matter of stratigraphical sequence all these raised beach deposits correspond to the raised coral reefs of Kume and Kikai.

Kume-jima

Geographical Situation and Topographical Features.

Kume lies 105 km. west of the harbour of Naha in Okinawa-jima in Lat. 26°13′—26°17′ N. and Long. 126°42′—126°49.5 E. It is roughly triangular in outline, measuring 13.5 km. from the southeastern end to the northwestern and 6 km. from Torishima[4] to Hiyajô[5] Topographically, it is divisible into a northern and a southern part by a lowland that stretches from Jima (or Gima)[6] to Janadô[7] beyond Yamagusuku.[8]

The Southern part is formed of Ara-dake,[9] a group of steep-sloped mountains, the highest of which is 287 m. The southeastern side of the mountain group has a remarkably high sea cliff, along the foot of which developed a narrow raised bench covered with boulders and shingles, while in the northern and eastern sides of it, terraces of 140 m. and 80 m. high are developed in the lowland between the two northern and southern parts of the island and along the east coast.

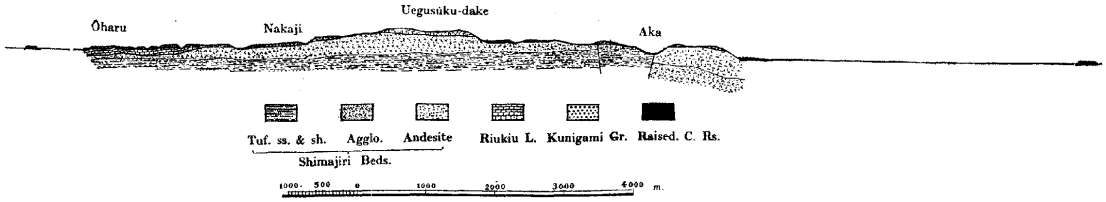
1) 崇元寺, 2) 榮野比, 3) 東恩納, 4) 鳥島, 5) 比屋定, 6) 儀間, 7) 射名堂, 8) 山城, 9) 阿良岳.

In the northern part of the northern division of the island, Uegusuku-dake,[1] a flat-topped and steep-sided mountain ridge, 309.5 m., extends in an east and west trend. It is flanked by a series of dissected coastal terraces, in steps, 120 m., 100 m., 80 m., 40 m., and 20 m. high on the north and west sides. Numerous dolines are developed on the surfaces of some of the lower terraces on the west side owing to their foundation being the Riukiu limestone. To the east of the summit of Uegusuku-dake are 240 m. and 120 m. terraces, the edges of which descend in high vertical cliffs straight to the raised coral reef near the village of Aka.[2] South of Uegusuku-dake, numerous successive terraces, 200 m., 160 m., 140 m., 120 m., 100 m., 80 m., 40 m., and 20 m. above sea level are developed and highly dissected by the Kategaru,[3] the largest river in the island. Along the east coast near Maja,[4] Une,[5] and Madomari,[6] we find below two unnamed hills, 219.7 m. and 160 m., low dissected terraces 60 m. above the sea. The height of the flat tops of Ôha and Wô, two dependent isles of Kume, are almost continuous with the surface of the last mentioned terraces.

The outstanding feature in the topography of Kume is the raised coral reefs, broadly developed along the coast of the northern part of the island, 500 m. or more in width and 20 m. in height. A barrier reef, 200—300 m. wide and 6 km. long, runs parallel with the southwest coast, from off the coast of Kanegusuku[7] to the west end of the island with a shallow boat channel or lagoon 500 m. in average width.

Another barrier reef quite similar to the preceding extends from the north of Ôha-jima towards the east for a distance of 10 km. The eastern termination of the barrier reef, where it bends southwards and then westwards again for a short distance, is called Ogan-zaki.[8] While the eastern barrier reef is entirely submerged in the sea at low tide, the western reef always stands above sea level.

In the matter of stratigraphical sequence the alluvial flat composed of sand developed at Jima and Jinta,[9] Hika,[10] and Janado correspond to the raised coral reef just mentioned.



4) Section across Kume-jima along line A—B in the Geologic Map.

Stratigraphy

Notwithstanding Mr. KUROIWA's report (Lit. 6) of an occurrence of schalstein in the southern division, my searches for an outcrop of it were in vain. As far as I am aware, the basement complex of the island consists of the Shimajiri beds. Kume is built up of the following formations, in descending order:

Raised Coral Reefs and Raised Beach Deposits.
Kunigami Gravel
Riukiu Limestone
Shimajiri Beds

Shimajiri Beds. The lower part of these beds exposed along a vertical cliff near Aka and on the scarps of the terraces near Maja, Une, Janadô, Hika, etc., is composed of fine and medium grained tufaceous sandstones and light-yellow, light-brown, yellowish-blue, and gray sandy shales,

1) 宇江城岳, 2) 阿嘉, 3) 嘉手刈, 4) 眞謝, 5) 宇根, 6) 眞泊, 7) 兼城, 8) 御神崎, 9) 銭田, 10) 比嘉.

often cross-bedded. A richly fossiliferous bed of a few meters thickness found in it along the sea cliff on the north coast near Aka, contained, besides bryozoa, many *Pecten satôi* YOKOYAMA, characteristic of the Byôritsu beds in Taiwan. These beds are said to be auriferous in places, containing gold placers. The tufaceous sandstones and shales pass upwards more or less abruptly into andesitic agglomerates without any stratigraphical break. That is to say, the upper part of the Shimajiri beds consists of andesitic agglomerates and andesite lavas, as exposed in the higher parts of the islands, e. g., at Uegusuku-dake, Ara-dake, etc. A mass of andesite that is exposed along a vertical sea cliff east of Aka, contacts with the tufaceous sandstones by means of a vertical fault plane. The foundation of Wô-jima is andesite, covered with gravels, sand dunes, and raised coral reefs. The strata of the Shimajiri beds are usually horizontal, although slightly inclined sometimes as may be seen near Maja and Aka, and often cut by normal faults.

Riukiu Limestone. These limestones unconformably overlie the Shimajiri beds, constituting the foundations of the western terraces. A number of huge blocks, found sporadically in the sea near the shore of the western part of the island and also north of Ôha-jima, consist of Riukiu limestone, usually compact and cavernous, white or light-brown, and containing many ill preserved reef corals

Kunigami Gravel. These gravels, covering the surface of the terraces, are only a few meters thick. It is a reddish-brown soil containing round pebbles of andesite and abundant manganese nodules, the latter being black spherical bodies, 0.5—1.5 cm. in diameter, and of concentric structure.

Raised Coral Reefs. These are similar in every respect to those of Kikai-jima. Stratigraphically the boulder covered raised bench along the southwest coast of Ara-dake probably corresponds to the raised coral reefs found in other parts of the island.

Tectonics.

Since the Shimajiri beds of this island comprise andesite lavas and its pyroclastic rocks, we know that the volcanicity in the inner row of the Riukiu Islands, to which Kume belong, first manifested itself in the late Shimajiri stage, probably late Pliocene. Although the upper parts of Uegusuku-dake and Ara-dake are capped with andesite lavas, the original position of the vent from which the volcanic materials were ejected cannot be ascertained with certainty.

As already stated in the forgoing pages, a deep sea over 1,000 m. lies very close to the northeast coast of the island and the eastern barrier reefs. This remarkable submarine feature may be considered as being closely related to a young crustal disturbance. The asymmetrical distribution of the Riukiu limestone in this island seems to strengthen this supposition If this supposition is admissible, the tectonic disturbance must then have occurred after the deposition of the Kunigami gravel, but prior to that of the raised coral reefs.

The Miyako Group.

Miyako-jima.

Geographical Situation and Topographical Features.

Miyako, the largest and easternmost island of the Miyako group, lies in Lat. 24°55′—24°42.6′.N. and Long. 125°29′—125°10.1′ E. It is roughly triangular in outline, the straight south coast running from east to west for a distance of 20 km. The northeast coast, 31 km. long, and trending generally N.W.—S.E., is almost straight, excepting a large embayment in its middle part. The

west coast is well indented with the three large embayments of Ôura-wan,[1] Harimizu-wan,[2] and Yonaha-wan,[3] all on the eastern side with straight coasts parallel to the general trend of the northeast coast of the island. Although from a distance, Miyako appears low and flat, it is nevertheless traversed by a number of linear ridges parallel to one another as well as to the general trend of the northeast coast of the island. All these ridges have nearly the same height (100 m.), invariably with a steep scarp on the east side, and a very gentle slope on the west that extends to the base of the east scarp of the next western ridge.

The greatest elevation of this island is attained by Nobaru-dake[4] (200 m.) in the middle of the island on one of these ridges.

Low narrow abrasion benches, a few meters above sea level, are intermittently developed along the shore.

Stratigraphy and Tectonics.

Miyako consists almost entirely of Riukiu limestone; karst topography being everywhere well developed. Soft, bluish-gray marls, with abundant minute foraminifera and a few mollusca, intermittently crop out along the base of the sea cliff on the east coast, with strike varying from N.W.—S.E. to N.—S. and a westward dip at angles 7°—20°. It is equivalent to the Shimajiri beds of Okinawa in its lighological and faunal characters.

Since the Riukiu limestone rests upon an uneven surface of the Shimajiri marls with different dip and strike, the two formations are unconformable.

Mr. Y. Oinouye (Lit. 24) recognized all the parallel ridges of the island as tilted blocks, and its steep eastern borders as fault scarps. This interpretation was also accepted by Mr. R. Aoki (Lit. 45) in his recent geomorphological study of the island.

The Kunigami gravel is nowhere to be seen on the island, the Riukiu limestone being usually covered with a reddish lateritic soil, probably a decomposition product of the limestone. Careful observation shows however that the gentle western slope of every ridge is terraced on the surface, which presumably were formed prior to the block movements of the Riukiu limestone.

The dependent islands, Ikeme, Kurema, Irabu, Shimoji, Minna, and Tarama are low, flat limestone islands not more than 20 m. at the highest point, and consisting entirely of Riukiu limestone.

The Yaeyama Group.

Iriomote-jima.

Geographical Situation and Topographical Features.

Iriomote, 25 km. from east to west and 18 km. from north to south, and lying in the middle of the Yaeyama group in Lat. 23°14.6′—24°26′ N. and Long. 123°39′—123°35.7′ E., has a smooth and almost straight south coast and well indented west, north, and east coasts, indicating the latest land-submergence. The island on the whole is mountainous with such prominences as Komi-dake[5] (4700 m.), Hateruma-mori[6] (450 m.), and Goza-dake[7] (420 m.). Dissected and divided by many rivers into numerous flat-topped ridges, these mountains from a distance appear like a plateau. Along the west and south coasts, all these ridges come to an abrupt end at steep slopes or precipitous cliffs, 200—400 m. high. But all along the north and east coasts, as well as along a part of the west coast from Aka-zaki[8] to Unari-zaki,[9] the dissected plateau is bordered by a high terrace. The terrace or marine abrasion bench, which is quite even on its surface, gently inclines seawards, ending

1) 大浦灣, 2) 張水灣, 3) 與那覇灣, 4) 野原岳, 5) 古見岳, 6) 波照間森, 7) 御座岳, 8) 赤崎, 9) 宇奈利崎.

in cliffs, 10—20 m. high, along the shore, the change in slope from its surface to the mountain side behind being abrupt. A conspicuous topographical feature of the island is that the valleys of such rivers as Nakara,[1] Kuira, Urauchi,[2] and Nakama[3] suddenly broaden in the lower courses to such an extent as almost to be narrow inlets for free entrance of sea water, permitting navigation of boats up to points 20 m. high, where the water course is always interrupted by a waterfall.

Stratigraphy.

Iriomote consists of the following formations, in descending order:

Raised Beach Deposits
Kunigami Gravel
Riukiu Limestone
Sonai Conglomerate
Yaeyama Coal-Bearing Beds
Palaeozoic Formation

Palaeozoie Formation. This formation occupies only the northeastern mountainous part of the island including Komi-dake, with good exposures along the northeast coast from Takana[4] to the south of Nobaru-zaki[5] and at Û-banare. It consists of intensely folded slates, phyllitic slates, crystalline schists, and crystalline limestone, the general strike being approximately E.—W.

Yaeyama Coal-Bearing Beds. These beds may be divided into two parts, the upper and lower. The lower part, which consists of andesite lavas, andesitic tuffs and agglomerates occasionally containing rounded pebbles of Palaeozoic rocks (mainly vein quartz), is found developed along the east coast between the south of Nobaru-zaki and the Shiira[6] River. The upper part, which shows a gradual transition from the lower, comprises gray and buff sandstones, gray thin bedded shales, and conglomerate containing subangular blocks of soft, gray shales directly derived from the underlying shales. The buff sandstones are occasionally cross-bedded, intercalating some workable coal seams. Two coal seams, each 1 m. thick, crop out at several places around Nakara-wan and the middle course of the Urauchi River, besides the common very thin ones a few centimeters in thickness. The Yaeyama coal-bearing beds are on the whole gently undulating, their dip and strike varying with place, and also crossed by many faults. These disturbances render difficult any correlation of the coal seams outcropping in separate places.

As already stated, S. TOKUNAGA (Lit. 12, p. 48) reported having found east of Sonai a thin layer of limestone full of *Lepidocyclina* in the Yaeyama coal-bearing beds which I, however, failed to rediscover as already stated.

Sonai Conglomerate. This conglomerate, composed of round pebbles (generally 1—2 cm. dia.) and occasionaly boulders (1 or 2 m. dia.) of hard compact limestones and hard sandstones, occurs only east of Sonai and at the north end of Uchi-banare, being marked off in both cases by faults from the Yaeyama coal-bearing beds, and overlain near Sonai by the Riukiu limestone. The limestone blocks are exactly the same as those found by S. TOKUNAGA just mentioned, both in lithological character as well as in the fossil contents. The fossils are

Lepidocyclina (*Nephrolepidina*) *taiwanensis* YABE and HANZAWA
Miogypsina inflata YABE and HANZAWA
Gypsina globulus REUSS
Cycloclypeus communis MARTIN (=*C. eidae* TAN SIN HOK)
Amphistegina radiata (FICHTEL and MOLL)

1) 仲良, 2) 浦内, 3) 仲間, 4) 高那, 5) 野原崎, 6) 後良川.

The fossil foraminifera faunule is one that is characteristic of the Kaizan beds of Taiwan of Middle Miocene. The Sonai conglomerate is therefore younger than the Yaeyama coal-bearing beds, but evidently older than the overlying Riukiu limestone. Although nearly horizontal near Sonai, it inclines northwards at an angle of 5° at Uchi-banare.

Riukiu Limestone. This limestone is very poorly developed on the island, occupying only the surface of the high level terraces or found as blocks scattered on them. What is found on the outer borders of the terraces (e. g., north of Sonai, Hoshitate,[1] near Uebaru)[2] is not stratified, but is an irregular aggregation of boulders, probably removed by erosion from the original position of the stratified limestone that once covered the terrace. The Riukiu limestone of this island is usually hard and cavernous.

Kunigami Gravel. As already stated, the 80 m. terrace is extensively developed in the northeastern half of the island; its surface being usually uncovered, although gravels are sometimes found on them, for instance, along the middle course of the Urauchi and along the east coast near Kasa-zaki[3] and Komi. The gravel bed near Urauchi is composed of round pebbles of reddish sandstones of the Yaeyama coal-bearing beds, while that near Kasa-zaki and Komi, consists of pebbles of Palaeozoic rocks and vein quartz, probably derived directly from the Palaeozoic formation and indirectly from the agglomerates in the lower part of the Yaeyama coal-bearing beds.

Raised Beach Deposits. These deposits are similar in occurrence and composition to those found in the other islands.

Hatoma-jima.

Hatoma, situated 5 km. northeast of Iri-zaki,[4] in Iriomote, is oval in outline, with its longer E.—W. axis 1.5 km. It is almost entirely composed of Riukiu limestone, the underlying buff sandstones of the Yaeyama coal-bearing beds cropping out only in its central hill, 35 m. in height.

Aragusuku-kanji-, Aragusuku-shimoji-, and Kuro-shima.

These are all small, low, flat limestone islands, consisting entirely of Riukiu limestone. In Kuro and Taketomi are saucer-like depressions in the middle of the islands.

Aragusuku-kanji, which lies 5.5 km. southeast of Nakama-zaki, in Iriomote, is elongated from N.E. to S.W. for 2.5 km., and attains a height of 15 m.

Aragusuku-shimoji, lying south of Kanji, is 1.7 km. in diameter and 20 m. in height.

Kuro, 4 km. east of Aragusuku-kanji, is 4.3 km. in diameter and 13 km. in height.

Kayama-jima.

Kayama-jima, a small, low, flat island, lying 2 km. north of Funa-zaki,[5] in Kobama, consists chiefly of Palaeozoic rocks, with a small patch of Riukiu limestone at the east end of the islet. This uninhabited islet is at present a cattle pasture.

The general surface of the islet, which is 10 m. in average height (maximum height 19 m.) was probably once flush with the 40—80 m. terrace near Funa-zaki, Kobama.

Taketomi-jima.

Taketomi, a small low, flat islet, 3.5 km. in diameter and 20 m. in height, is chiefly composed of Riukiu limestone, while Palaeozoic rocks are exposed at the northern tip and at the center of the island. The general surface of the islet which cuts uniformly both the Riukiu limestone and the

1) 千立, 2) 上原, 3) 笠崎, 4) 西崎, 5) 舟崎.

Palaeozoic rocks, was once flush with the 40—80 m. terrace of southern Ishigaki.

Kobama-jima.

Geographical Situation and Topographical Features.

Kobama lies east of Iriomote, from which it is separated by the narrow strait of Yonara,[1] 2.5 km. wide. The dome-shaped mountain Ô-dake[2] that rises from the middle of the islet is 100 m. high and more or less steep-sided. It is surrounded by an extensive terrace (60 m. high) that descends outwards to low sea cliffs, at the most 30 m. high, and at the base of which is a narrow raised abrasion bench, 5 m. above sea level.

Stratigraphy.

Kobama is composed of the following formations, in descending order:

Raised Beach Deposits
Kunigami Gravel
Riukiu Limestone
Yaeyama Coal-Bearing Beds
Miyara Beds
Palaeozoic Formation

Palaeozoic Formation. A series of folded and contorted slates, phyllites, and crystalline schists that form Ô-dake are also exposed in the northeastern and southeastern parts of the island, its strike and dip varying with place, the general strike however being approximately E.—W.

Miyara Beds. S. TOKUNAGA (Lit. 12, p. 46) reported a *Lithothamnium*-limestone from near the village of Kobama, similar to that of Miyara in Ishigaki-jima. A similar hard and light-gray *Lithothamnium*-limestone (containing abundant *Archaeolithothamnium* and subordinate *Lithothamnium*, *Lithophyllum*, and other calcareous algae) is exposed near the beach of Sakora.[3] Another hard and variegated limestone, containing abundant remains of foraminifera, *Pellatispira*, *Discocyclina*, *Camerina*, etc., as also *Archaeolithothamnium*, *Lithothamnium*, *Lithophyllum*, etc., are found on this beach. The intervals between these limestones are covered and concealed beneath the Riukiu limestone. The *Pellatispira*-limestone which, in its lower part, is rich in rounded pebbles of Palaeozoic rocks, becomes a conglomeratic limestone. The sandstones in the Miyara beds of Ishigaki, are not associated with the *Pellatispira*-limestone of Kobama. North of Sakora, the Eocene limestone is tilted at a steep angle and entirely surrounded by Riukiu limestone. The stratigraphical relation between the Miyara beds and the Yaeyama coal-bearing beds is however unknown.

Yaeyama Coal-Bearing Beds. The slender promontory Kuba-zaki[4] and the hilly country west of the village of Kobama are both built up of andesite, and andesitic agglomerates without stratification and granophyre. These agglomerates are also intercalated in tufaceous sandstones, south of the village of Kobama, the series passing upwards to buff sandstones and conglomerates with pebbles of vein quartz. A very thin coal seam is interbedded in the sandstones near the mouth of a small stream north of Ukan-zaki.[5] These sandstones and conglomerates are either nearly horizontal or slightly inclined in various directions. The andesite and pyroclastics of Kuba-zaki and of the hilly land west of the village of Kobama may be correlated with those exposed on the east coast of Iriomote between Kasa-zaki and Nobaru-zaki, opposite Kuba-zaki. The

1) 與那良. 2) 大岳.
3) Sakora, which is the local name for *Tridacna*, is also the name of the place where this mollusc is caught in great abundance.
4) Kuba or Kuva (細) means slender in the language of Yaeyama. 5) 御拝崎.

buff sandstones, and the conglomerates of Kobama with a thin coal seam may be equivalent to the coal-bearing beds of Iriomote and Yonaguni.

Riukiu Limestone. This is more or less widely distributed in the island, forming the foundation of the high level terrace. It consists principally of remains of reef organisms, foraminifera, bryozoa, reef-building corals, mollusca, and calcareous algae; occasionally containing pebbles of Palaeozoic rocks in the basal part where it rests directly on the erosion surface of the Palaeozoic formation. The thickness of the Riukiu limestone in the island is estimated to be from 10 to 30 m.

Kunigami Gravel. This is a thin gravel bed, with pebbles of Palaeozoic rocks partly covering the Riukiu limestone and partly the older rocks of the high level terrace.

Raised Beach Deposits. This calcareous deposit of fragmental remains of reef organisms is occasionally found veneering the low raised abrasion benches, as near Ukan-zaki for example.

Ishigaki-jima

Geographical Situation and Topographical Features.

Ishigaki-jima lies at the eastern end of the Yaeyama group, Lat. 24°01′—24°37′ N. and Long. 124°04′—124°20.4′ E. The main body of the island, which is subquadrangular in outline, is 13.5 km. wide, measured along its E.—W. and N.—S. sides. Extending northwards from the northeastern corner of the main body is a long peninsula 19 km. in length, and 5 km. and 0.4 km. in its maximum and minimum widths (the isthmus of Ibaruma)[1] respectively, and which for convenience may be called the Ibaruma Peninsula. Two smaller peninsulas project northward and westwards from the northwestern corner of the main body, the former called Kapira[2] and the latter Yarabu[3]. Both are 5 km. long and 2.5 km. at the widest part. A high ridge along the northern side of the main body of the island has its steep northern and southern sides descending rapidly to the coastal terrace and the central basin respectively. The high points of this island are located on this ridge, the most prominent one being Omoto-dake[4] (520 m.). The average height of the ridge is 400 m. Steep sided mountains are aligned on an E.—W. line north of the town of Ishigaki, their highest points being Banna-dake[5] and Mase-dake[6], both 200 m. The space between these mountains and the northern ridge is occupied by a terrace 80 m. high. On another terrace 80 m. high, between Tôsato[7] and Moriyama[8], are studded seven steep-sided hills; Kara-dake, the highest being 135 m. The Ibaruma Peninsula has a steep-sided backbone ridge running almost through its entire length, with an average height of 200 m., the high points being Nosoko-dake[9] (280 m.) and Hattsua-dake (365 m.). The ridge comes down at the isthmuses of Ibaruma and Uchino[10], where it is less than 80 m. high. The greater part of the Yarabu Peninsula is mountainous, its highest point being Yarabu-dake (215 m.) The Kapira Peninsula, which is mountainous in its northwestern tip and in its southern part, attains a maximum elevation of 260 m. south of the village of Kapira.

The mountainous sections just enumerated, which occupy a considerable area of the island, are almost everywhere surrounded by coastal terraces. Narrow belts of coastal terraces, 80, 40, or 20 m. high, are well developed around the backbone ridges of the Ibaruma Peninsula and in the north coast of the main body of the island. In the Kapira Peninsula, north of the village of Kapira, is a broad terrace of 20 m. The Yarabu Peninsula is connected to the main body of the island by a neck whose height is 40 m., while its mountainous part is surrounded by a narrow coastal terrace 20 m. high. A broad terrace, 80 m. above sea level and well developed in the main body of the island below the steep mountain slope, is very extensive in its southern part.

1) 伊原間 ,2) 川平, 3) 屋良部, 4) 於茂登岳, 5) 萬那岳, 6) 萬勢岳, 7) 桃里, 8) 盛山, 9) 野底岳, 10) 內野.

Low raised abrasion benches are scarcely developed around the island, the few that are found being only along its south coast.

Stratigraphy.

Ishigaki is composed of the following formations, in descending order:

Raised Beach Deposits
Kunigami Gravel
Riukiu Limestone
Yaeyama Coal-Bearing Beds
Miyara Beds
Palaeozoic Formation

Palaeozoic Formation. This formation consists of intensely deformed slates, sandstones, crystalline schists, crystalline limestone, and radiolarian cherts, varying in strike and dip with place, although the general strike is nearly E. and W. Except that the radiolarian cherts in thin slices under the microscope show minute lucid spots, presumably radiolarian remains, the crystalline limestone and other rocks contain no fossils. It is intruded by granitic rocks, such as quartz-, and quartz-augite-monzonite, and quartz-diorite, all extensively exposed in Omoto-dake and its neighbourhood. The mountainous parts and the hilly country of the main body of the island as well as the Kapira Peninsula are almost entirely composed of these Palaeozoic rocks.

Miyara Beds. This is a complex of *Pellatispira*-limestone in several layers, interbedded soft buff sandstones, and variegated conglomerates with round and subangular blocks of Palaeozoic rocks. The *Pellatispira*-limestone, which is gray, and compact, occasionally contains *Archaeolithothamnium*, *Lithothamnium*, *Lithophyllum*, etc., as in that from Kobama. These beds are exposed as isolated patches at Miyara, Tôsato, Ibaruma, and two other places, 2.2 km. and 1.5 km. respectively northeast of the town of Ishigaki, either directly overlain by the Riukiu limestone or lying underneath it, generally with steep dip and various strikes. The bronzite-andesite found north of Miyara beneath the Riukiu limestone is probably a flow into the Miyara beds.

Yaeyama Coal-Bearing Beds. These are soft, buff sandstones with coaly substances, cropping out under the Riukiu limestone north of the town of Ishigaki. Lithologically, they resemble the sandstones of the Yaeyama coal-bearing beds of Iriomote, Kobama, Hatoma, Yonaguni, etc. Although they also are almost indistinguishable from the soft sandstone interbedded in the *Pellatispira*-limestone, the former is almost horizontally bedded, while the latter is usually steeply inclined, containing no coaly substances. The thin banded gray tufaceous sandstones of the hilly country near Nobaru-zaki on the east coast belong to the same coal-bearing beds, the strike being nearly E.—W. with a southward dip of 26°. Following these tufaceous sandstone westwards along the strike, we encounter, north of Tôsato, a large mass of *Pellatispira*-limestone. The latter crops out also in a valley bottom of nearly N.—S. trend, north of Tôsato. It being difficult to believe that the limestone and sandstone, which are contiguous with nothing between them, could have altered each other at such a short distance, and in the absence of any distinct trace of a fault along the valley, the reasonable assumption seems to be that the tufaceous sandstone rests on an erosion surface of the *Pellatispira*-limestone.

Although the greater part of the mountainous tract of the Yarabu Peninsula and the backbone ridge of the Ibaruma Peninsula is built up of andesite, andesitic tuffs and agglomerates, the pyroclastic rocks being destitute of fossils and coal, the exact stratigraphical position of these rocks is not known. These volcanic materials, as also the soft buff sandstone with coaly substances found north of the

town of Ishigaki and the tufaceous sandstones of Nobaru-zaki, may all belong to the Yaeyama coal-bearing beds, and not to the Miyara beds, seeing that similar rocks are found in the Yaeyama coal-bearing beds of Iriomote and Kobama.

Riukiu Limestone. This is extensively developed, forming the foundation of the high level terrace, especially in the southern part of the main body of the island ; the commonest kind being a white cavernous limestone with foraminifera, corals, and other reef organisms. Large specimens of *Cycloclypeus carpenteri* are abundant in the Riukiu limestone from Hirai[1] near the south coast.

Kunigami Gravel. The high level terraces of the island are occasionally covered with a gravel bed of pebbles of Palaeozoic rocks, granitic rocks, and Riukiu limestone, the terrace along the northern coast of the main body of the island near Fukai[2] and Nakasuji[3] being strewn with fine quartz sands derived from the mountains lying behind the terrace.

Raised Beach Deposits. The low raised bench along the southern coast of the island is built up of a calcareous deposit composed of foraminifera and fragments of reef-building corals.

Hateruma-jima.

Geographical Situation and Topographical Features.

Hateruma, a low flat limestone island, lying at the southern end of the Riukiu Archipelago, in Lat. 23°03′—23°01′ N. and Long. 123°45′—123°48.8′ E., is roughly elliptical in outline, its longer axis (6 km.), running from east to west with its maximum width (3 km.) at the middle part. Its highest part (50 m.), situated about the center of the island, has developed around three successive terraces, 40 m., 20 m., and 5 m. above sea level, even the highest part being noticeable as a terrace.

Stratigraphy.

The foundation of the island consists of a reddish medium grained sandstone, cropping out thinly under Riukiu limestone near the village of Hoka[4]. Lithologically, the sandstone is quite similar to the sandstones of the Yaeyama coal-bearing beds from Iriomote and Yonaguni. The greater part of the island is built up of Riukiu limestone, consisting of abundant remains of reef corals, foraminifera, and other coral reef organisms, and is partly phosphatized.

The lowest coastal terrace, 5 m. high, is covered with a hard compact coralline limestone, a few meters in thickness. This limestone, consisting of foraminiferous tests and fragments of reef-building corals, corresponds to the raised coral reefs of Kume and Kikai in stratigraphical sequence.

Yonaguni (or Yonakuni)-jima.

Geographical Situation and Topographical Features.

Yonaguni, an island at the western end of the Riukiu group in Lat. 24°28′—25°08′ N. and Long. 122°56′—123°02.6′ E., has its longer axis (11.5 km.) extending E.—W. and an average N.—S. width of 4 km.

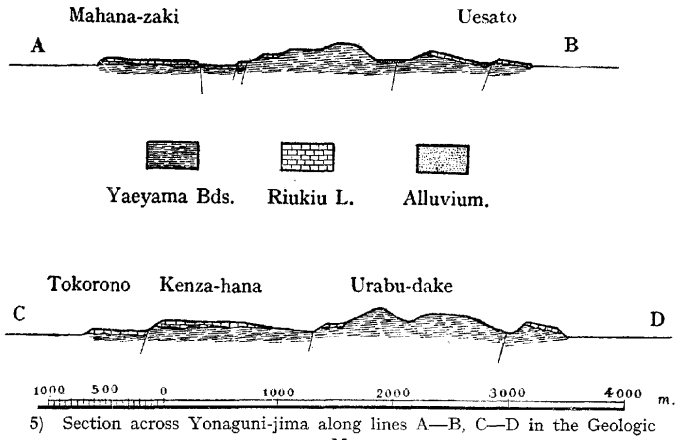
Urabu-dake[5], the greatest elevation (231.3 m.) and situated in the central part of the island, rises like a dome from the general level of the high ridge near by. Excepting Urabu-dake, just mentioned, Yonaguni consists of many flat-topped ridges and table-lands, trending E. and W. or nearly so. South of Urabu-dake, a high ridge of 150 m. average elevation stretches from the village of Hinai[6] to Warime[7] with an E.—W. trend, while south of it and beyond a flat-bottomed valley, the other high ridges (90 m. to 140 m. in height) align themselves from Arakawa-hana[8] to Warime

1) 平得, 2) 桴海, 3) 仲筋, 4) 外, 5) 宇良部岳, 6) 嵩川, 7) 割目, 8) 新川鼻.

with an E.N.E.—W.S.W. trend. Another series of ridges (130 m. high) south of the highest ridge just mentioned, extends with an E.—W. trend from Hinai to Arakawa-hana. The edges of these series of ridges, flanked by a continuous narrow, shingle-covered, raised abrasion bench, 5 m. above the sea, fall in lofty vertical cliffs along the south coast of the island. Northeast of Urabu-dake is Hoan[1], a broad flat-topped 60 m. hill, bordered by a flat-bottomed valley with a low scarp on the north, its surface sloping down very gently to the other flat-bottomed valley in the south. A broad table-land (30 m. high) along the north coast of the island east of the village of Sonai, ends at a 40 m. fault scarp, in a N.—S. trend, west of the high flat-topped ridge of Yateku[2]. The latter, 90 m. high, extends from the fault scarp to Agari-zaki[3], the eastern end of the island. The north sides of the ridge of Yateku and the table-land to the east of Sonai are bordered by a continuous vertical sea cliff, while narrow and low raised benches, occasionally strewn with shingle and gravel, are intermittenly developed along the foot of the sea cliff.

In the middle of the island, south of the village of Shimanaka[4], is a broad plateau, 60 m. high, and separated from Urabu-dake by a broad flat-bottomed valley with a N. W.—S. E. trend. West of the plateau, are two parallel ridges with an E.—W. trend, the northern one of which is lower, with an average elevation of 140 m., and the southern one flat-topped, average 180 m., with a prominent point (186 m.) called Kubura-dake[5]. South of Kubura-dake and west of the village of Hinai, are two other parallel ridges (80 m. high) running E. to W. and separated from each other by a flat-bottomed valley. Built up chiefly of Riukiu limestone, these two ridges are tilted southwards, their southern sides gently descending with the dip slope of the Riukiu limestone, while the northern margins are very steep vertical fault scarps. The gentle slope of the southern ridges is bordered by a steep sea cliff in the southern margin of its western half. At Akazaki[6], northwest of Hinai, is another small ridge with an E.—W. trend, also built up of Riukiu limestone, tilted southwards, and exhibiting similar topography. South of the village of Kubura is a broad plateau-like hill that continues at the same level to the northern ridge of the Riukiu limestone just mentioned.

The surface of the promontory that juts into the sea on the south side of the bay of Kubura, gently descends eastwards with the dip slope of the sandstones of the Yaeyama coal-bearing beds of the foundation. A table-land, 20 m. high, that extends northeastwards from the village of Kubura is separated from Kubura-dake by a broad trough running parallel with the trend of the former. The northeastern end of the eastern border of the plateau of Shimanaka just mentioned, and forming a high cliff that faces the valley of Sonai, is called Kenzahana[7]. This cliff, which is continuous from Kenzahana westwards, diminishes in height as the plateau surface very gently slopes down westwards. The westward extension of the surface of the plateau moreover becomes so low as to form the bottom of a trough lying between the table-land to the north of Kubura just mentioned and the western part of the terrace lying between Tôbaru[8] and the bay of Sonai and extending for a distance of 4.5 km. with height 20—



5) Section across Yonaguni-jima along lines A—B, C—D in the Geologic Map.

1) 帆安, 2) 屋手久, 3) 東崎, 4) 島仲, 5) 久部良岳, 6) 赤崎, 7) 險座鼻, 8) 桃原.

40 m. above sea level. The low scarp facing south and bordering the north side of this trough lies in the western extension of the high cliff facing north (of Kenzahana) and flanking the northern rim of Shimanaka plateau, whereas in contrast to it, the low scarp facing north along the southern border of the same trough lies in the western extension of the north side of the ridge to the north of Kubura-dake. Shimanaka plateau is dissected by a deep gorge with a N.—S. trend at a place 1.5 km. west of Kenzahana.

Stratigraphy.

Yonaguni consists of the following formations, in descending order:

Recent Deposits
Riukiu Limestone
Yaeyama Coal-Bearing Beds

Neither Palaeozoic formation nor the Miyara beds is found in the islands, the Yaeyama coal-bearing beds forming the largest part of it.

Yaeyama Coal-Bearing Beds. These beds comprise light-brown and greenish-gray sandstones and grayish-blue shales. The dip angles, which are always small, vary greatly in direction. A thin coal seam, 30 cm. thick, interbedded in the sandstones, crops out on the sea cliff south of Hoan-uebaru.[1] An impure limestone, about 20 m. above the coal seam, contains abundant remains of *Operculina* that strongly recall *Operculina bartschi* CUSHMAN var. *multiseptata* YABE and HANZAWA, together with some ill preserved molluscs and echinoids. Lithologically the Yaeyama coal-bearing beds are quite similar to the coal-bearing Tertiary of Iriomote and Taiwan.

Riukiu Limestone. This limestone, mainly composed of hard cavernous white limestone, unconformably overlies the preceding beds. The terraces or plateaus along the north coast and the southwardly sloping ridges, or tilted blocks, in the southwestern part of the island mainly consist of this limestone, with the Yaeyama coal-bearing beds exposed under this limestone, forming the basal part of the scarps or cliffs around the terraces or ridges. The small patches of the same limestone sporadically appearing on the tops of the high ridges are erosion remnants. The Riukiu limestone of this island contains abundant remains of reef corals, well preserved specimens of which may be collected on the plateaus and terraces.

Recent Deposit. There is no gravel that could difinitely be assigned to the Kunigami gravel of this island. The gravel beds one occasionally sees in the valley bottoms lying between the many blocks already mentioned differ considerably from the Kunigami gravel, consisting of pebbles of a brown sandstone derived from the underlying Yaeyama coal-bearing beds. The surface of the plateaus or terraces and the flat-topped ridges, although not covered with any deposits except residual soil, beveled the deposition planes of the Riukiu limestone and the Yaeyama coal-bearing beds after the deposition of the Riukiu limestone, namely, in the post-Riukiu stage. The block movement that cut the island into many blocks as just mentioned is a later event.

1) 帆安上原.

The Ôsumi Group.

Introduction.

After the manuscripts of the foregoing chapers had been completed, I availed myself of an opportunity to carry out stratigraphical surveys in Tane-ga-shima during a fifty days stay in the island from November 2 to December 23, 1933, and also during a week's stay in Yaku-shima, from December 24—30. The expenses of my trip to these islands were guaranteed by the Foundation for the Promotion of Scientific and Industrial Research of Japan, to the council of which I express here my sincere gratitude. I should like at the same time to thank Professor H. YABE for his criticisms and for his painstaking work of looking over the manuscript. My thanks are also due to Messrs. S. NOMURA, S. MABUTI, and N. ZINBÔ, to whom I am greatly indebted for their specific determinations of mollusca.

Tane-ga-shima

Geographical Situation and Topographical Features.

Tane is a long island in Lat. 30°50′—30°20′ N. and Long. 131°05′—130°52′ E., extending in a N.N.E.—S.S.W. direction with its longer axis of 57 km. from On-zaki,[1] the north end of the island, to Kadokura-zaki,[2] the south end, and with its maximum width, 12 km., in two places, the one on a line from Sumiyoshi[3] on the west coast to Hirayama[4] on the east, and the other on a line from Shimama-zaki[5] on the west coast to Hamada[6] on the east, the minimum width 6.5 km., being the isthmus of Noma[7] that lies between the two broadest parts. On-zaki lies 40 km. southeast of Sata-misaki,[8] the extreme south of Kyûshû, beyond the Ôsumi Strait (Van Diemen St.). Tane-ga-shima Strait (Vincennes St.), between the west coast of the southern portion of Tane and the east coast of Yaku, has an east to west width of 18 km.

This island is on the whole low and flat, even its greatest elevation, which is west of the village of Jûsanban,[9] being only 282.3 m. The coastal line of the island is generally monotonous, the coasts of most of the island being straight, in all probability the result of late geologic tectonic lines, although the presence of a number of coastal indentations point to recent land-submergence. The smooth coasts, the south coast between Honmura[10] and Takezaki[11] and along Nagahama[12] (meaning long beach), i. e., the middle part of the west coast between Takenokô[13] and Yakutsu,[14] for example, consist of recent deposits that have filled the valley-hollows in the subsiding surface of the older rocks. Besides sand beaches, narrow raised abrasion benches, 10—20 m. high and 100 m. broad, uniformly surround the island, their surface being largely bare; but in some places covered with gravels and in a single case, south of Azakô[15] on the east coast, with small patches of limestone containing *Baculogypsina sphaerulata* (PARKER and JONES), *Amphistegina radiata* (FICHTEL and MOLL), and calcareous algae.

Tane is topographically divisible into three divisions, northern, middle, and southern. The northern division comprises part of the island lying north of a straight scarp facing southwest, 60 m. high, extending from Ôbirono[16] on the west coast to Tanowaki[17] on the east; the middle division, the other part lying south of the scarp just mentioned and north of the other straight scarp facing southwest, 40 m. high, reaching from Haruta[18] near the west coast to Nakayama[19] on the west; the southern division, being the other part lying south of the last mentioned scarp.

The Northern Division : The greater part of the northern division consists of a dissected

1) 御崎, 2) 門倉崎, 3) 住吉, 4) 平山, 5) 島間崎, 6) 濱田, 7) 野間, 8) 佐多岬, 9) 十三番, 10) 本村, 11) 竹崎, 12) 長濱, 13) 竹之川, 14) 屋久津, 15) 浅川 16) 大廣野, 17) 田ノ脇, 18) 春田 19) 中山.

plateau, with its highest point 237.9 m. above sea level, at Amame[1] shrine in a ridge near its southeastern corner, and which very gradually diminishes in height from southeast to northwest. In the northern and northwestern sections of this division are developed two dissected coastal terraces, 20 and 60 m. high, the higher of which is continuous with the surface of the plateau without any line of demarcation between them. South of Amame shrine and west of the village of Annô,[2] is a high dissected terrace, the northwestern border of which is limited by a straight scarp in a N. E .—S. W. trend, and which is the margin of the plateau just mentioned, its eastern rim descending to the coastal terrace, 60 m. above sea level, with scarps, 60 m. high, while its southwestern border is the southeastern continuation of the scarp that is delimited by the southwestern side of the said plateau. The surface of this highly dissected terrace also inclines very gently northwestwards, namely, to the opposite direction to the east coast. Along the east coast from Shôjiura[3] to a point 3 km. north of Hamawaki,[4] is a broad coastal terrace, moderately dissected and flanked by scarps delimiting the eastern side of the plateau and the high terrace. Although the height of these scarps that delimit the western border of this coastal terrace is 60 m. near Annô, as already mentioned, it suddenly becomes 120 m. or so west of Guniwa[5] owing to the terrace being directly flanked by the plateau, diminishing suddenly again, north of this locality, to 60 m. The surface of the low coastal terrace inclines from south to north, its height being 80 m. above sea level near the south end, 60 m. near Okigahamada,[6] and 40 m. near the north end. The coastal terrace south of Guniwa is in two steps of low scarps, 80 m. and 40 m. high above the sea.

The Middle Division. As already stated, the greatest elevation of the island, 282.3 m., is found west of the village of Jûsanban, rather nearer the west coast as reckoned from the center of this division. Around it is developed a series of highly dissected terraces or plateaus, in steps, 260, 240, 180, 160, and 80 m. high above sea level. The lowest terrace is symmeterically developed with an uniform breadth of 1 km. along both the east and west coasts, although in places there is no terrace at all owing presumably to their disappearance as the result of late crustal disturbances. As to all these terraces, with the exception of the 80 m. one, their developments are asymmetrical along the east and the west coast, that is all the western terraces are narrower than the eastern. The surface of the 160 m. terrace lying north of a line from Yokino[7] to Hiramatsu[8] slopes down very gently northward to the flood plain of the river that runs from Hajinomine[9] to Azakô along the foot of the scarp extending from Ôbirono to Tanowaki.

The Southern Division. The middle part of the isthmus of Noma is a broad table-land, 120 m. above sea level, that diminishes very slowly in height towards both the east and west coasts without any scarps. Towards the north, this table-land also decreases in height, its extent being delimited by the scarp at the southern margin of the middle division. South of it, this table-land is bounded by a straight scarp, 40 m. high, facing southwest with a direction N. W.—S. E. for a distance of 4 km. and close to the villages of Miza[10], Mitariyama[11], and Yuku[12]. South of Miza is developed an even plain, 100 m. above sea level, reaching to the villages of Tajima[13] and Sakai[14], its surface level being almost continuous with that of a highly dissected coastal terrace developed along the east coast as far as Take-zaki, the southeastern extremity of the island. Southwest of Tajima and Sakai, we meet with a flat-topped ridge, 124—144.7 m. in elevation, that delimits this even plain with a gently sloping scarp extending form Sakai to Nishiyama[15] in a N. W.—S. E. direction. The area that lies south of the flat-topped ridge is the southernmost section of this island, the western half of which mostly consists of a moderately dissected plateau. An even surface, 200 m. high, extends in a meridional

1) 天女神社, 2) 安納, 3) 庄司浦, 4) 濱脇, 5) 軍場, 6) 沖ケ濱田, 7) 能野, 8) 平松, 9) 爐ノ峯, 10) 美座, 11) 滿足山, 12) 油久, 13) 田島, 14) 坂井, 15) 西山.

direction through the whole area of the plateau region, although it is divided by steep-sided valleys and the lower even plain of Kaminaka[1] 150 m. high. Although the plateau region is now separated from the said flat-topped ridge close to Sakai and Tajima by the broad valley of the Fukawa[2] River and the lower plain of Nakada[3], its surface descends very slowly to the same level as that of the flat-top of the ridge, whence it may be reasonably supposed that the latter was at one time continuous with the former. Along the northwest coast of the plateau region from Yakutsu to Ushino[4] is a coastal terrace 80—100 m. in elevation and 1 km. in width, the rise towards the plateau, 160 m. high, being a series of steps in somewhat illdefined scarps. The southern continuation of the lower terrace, developed along the west coast from Ushino to Kadokura-zaki, ends in the east at a plateau 200 m. high with steep scarps of 100 m. in height without any intermediate terraces.

The two broad flat-bottomed valleys of Kukinaga[5] and Kôribaro[6] are, as already mentioned, submerged valleys filled with recent deposits. Along the even coast from the south of Shimonaka[7] to the south of Honmura are developed low and narrow ridges formed of sand dunes with an average width of 200 m. and a height of 10 m., and traversed by the Shikanaki[8] River.

Homan-no-ike[9], which is noted in the island for its picturesque scenery and as a duck-pond, is near the south coast of the island. This pond, in my opinion, was formed by the banking up of sand dunes across the lower course of a valley cutting into the conglomerates and sandstones of the Kukinaga beds.

In the northern and middle divisions are two systems of linear valleys, the one with a direction N. 10°—30° E., and the other N. W.—S. E. The former direction coincides exactly with that of the axes of the foldings and faults of the Kumage beds, which form the foundation of these regions, the latter, with that of the prevailing joints having developed in the same beds.

In the western and northwestern parts of the southern division is developed a system of valleys with a N. 50°—60° E. trend that also coincides with the strike of the Kumage beds developed as the foundation of this region.

There are three linear parallel valleys of the Miyase,[10] Kôri[11], and Shikanaki Rivers, all in meridional direction in the southern part of the southern division. As will be clear from a study of the geological structure of this district, the trend of the valleys depends on that of the normal faults that cut the Kukinaga beds.

A linear valley of the Shimama River, which runs with a N. W.—S. E. trend, strongly suggests tectonic origin, although I did not succeed in securing any data that could confirm my conclusions based on my own field observations.

Stratigraphy.

Tane-ga-shima consists of the following formations, in descending order:

Recent Deposits and Sand Dunes
Kaminaka Beds[12]
Kukinaga Beds[13]
Kumage Beds[14]

Kumage Beds. The basement complex of this island, principally composed of thin-bedded, hard, compact, black and dark-gray shales, with subordinate hard, compact, light-brown and gray fine-grained sandstones, intensely folded, and cut by numerous faults, both reverse and normal.

1) 上中, 2) 深川, 3) 中田, 4) 牛野, 5) 茎永, 6) 郡原, 7) 下中, 8) 鹿鳴, 9) 寶満之池, 10) 宮瀬, 11) 郡, 12) 上中層群, 13) 茎永層群, 14) 熊毛層群.

In the northern half of the island, the strata of these beds generally strikes parallel to the longer axis of the island with a N. 10°—30° E. trend, although with local deviations, and vertical and steep westwards dips, while in the southern half, the normal trend of the strike of the strata strongly deviates, assuming a N. 50°—70° E. trend. Not rarely, these strata dip either vertically or are generally directed southwards or northwards at steep angles. At places in the southern half of the island, the strata are so intensely deformed as to result in crush breccias or conglomerates.

These Kumage beds, forming the greater part of the foundation of the plateaus, terraces, and abrasion benches, is almost unfossilliferous. Only one fossil record, that of the occurrence of fossil fishes in these beds, has been furnished by the late Mr. S. SAHEKI (Lit. 37), who described two new species of fishes, *Clupea tanegashimaesis* and *Pereichtys chibéi*, from these beds in a road-cutting north of Sumiyoshi near the west coast, and from which he tentatively assigned the beds to Lower Miocene or older.

These beds differ entirely from the Palaeozoic formations in Okinawa and the other islands of the Riukiu Arc in that the rocks of the former present nowhere any foliation or schistosity, thus showing evidence of a younger age than the latter. The age of the Kukinaga beds, which may safely be assigned to the Burdigalian, occurs in detached areas and filled up hollows in the submerged surface of the intensely deformed Kumage beds. Although the exact geological age of the Kumage beds is as yet uncertain, judging from the stratigraphical and palaeontological evidences just given, we may refer it to the Akitsu Period (Japanese Palaeogene) (Lit. 25).

I made attempts to subdivide the Kumage beds, which seemed possible, seeing that the beds sometimes consist of thin-bedded shales alone and at other times of an alternation of banded sandstones and thin-bedded shales, but owing to the strata being too badly deformed, had to abandon the idea. For the same reason the thickness of the beds has not yet been determined. These beds on the whole are isoclinally folded, being exposed at several places in profile across the island, from which the thickness of the beds may be inferred as being not very considerable.

Igneous rocks are very scarce in Tane-ga-shima. Trachydolerite outcrops in a small way from between dislocated shales in the Kumage beds in only two places, both valley bottoms, one southeast of Ôbirono and the other northeast of Fukagawa[1]. Judging from its mode of occurrence, however, I am not certain whether the igneous rock intrudes into the Kumage beds or whether the latter unconformably rests on an erosional surface of the former. Personally, I am inclined to the opinion that the former intruded into the latter, after which both were dislodged by a crustal movement—an opinion based on the fact that in this island no deposits older than the Kumage beds have been found that seem to have been intruded by igneous rock. The trachydolerite which is hard, compact, dark green, and mottled with many minute white spots, is quarried for building- and tomb-stones.

Before the Kukinaga beds were laid down on the Kumage beds, the rocks of the latter beds had been folded, faulted, elevated, and then subjected to a long period of erosion. This period of disturbance and denudation corresponds to that between the Miyara and the Yaeyama coal-bearing beds in the Yaeyama islands, also to that between the Karisan shale formation and the Kaizan beds in Taiwan (Formosa), as well as to that called by Prof. H. YABE and Mr. R. AOKI (Lit. 25) the Takachiho Period of Emergence.

Kukinaga Beds. These beds, which rest on the highly denuded surface of the much folded Kumage beds, occupy a large area in the eastern half of the southern division with several small detached areas on and near the east coasts of the northern and middle divisions; namely south of

1) 深川.

Annô, along the beach at Shôjiura, the neighbourhood of Bubu[1], the village of Anjô[2], and along the coast from Injô[3] to Masuda[4]. Lithologically, it is very easily distinguished from the foregoing beds, consisting as it mainly does of an alternating series of variegated conglomerates and gray and light-brown sandstones, with subordinate dark-gray clay, besides some thin coal seams of inferior quality. Generally, the conglomerates and sandstones being only slightly consolidated, they become in places sands and gravels. The materials forming these rocks are evidently derived from the Kumage beds underlying them. Whereas these sandstones and conglomerates have not as yet yielded any fossils, the clays, besides being fossiliferous, sometimes contain abundant remains of *Ostrea gigas* THUMBERG as well as plant remains, so that they have been called *Ostrea* beds. In a sea cliff south of Injô is exposed an *Ostrea* bed interbedded in soft sandstones and conglomerates. In this *Ostrea* bed are found a number of *Vicarya callosa* JENKINS, an important gastropod species widely distributed in the lower part of the Mizuho Series (Japanese Neogene) in Honshû, together with a number of *Ostrea gigas* THUMBERG. The same *Ostrea* bed, but containing only *Ostrea gigas*, is found near Kawachi[5], Kaminaka, Kukinaga, and west of Hirayama, all in the southern division (the exact fossil localities are plotted in the accompanying geological map). In a clay interbedded in the sandstones and conglomerates exposed on the road leading from Masuda to Injô are found some mollusca *Arca* (*Arca*) cf. *abdita* MAKIYAMA, *Cerithidea* cf. *cingulatum* (GMELIN), and *Batillaria* cf. *zonalis* (BRUGUIÈRE), and in a similar bed southeast of Sakai, *Arca* (*Arca*) *daitokudoensis* MAKIYAMA and *Toras semiasperoides* (NOMURA). No *Ostrea* and *Vicarya* have however been found in these localities. The plant-remains just mentioned are found in poorly preserved condition in a clay exposed in a road-cutting a little south of the easternmost corner of the great curves east of the village of Kaminaka, and which is regarded as belonging in the same horizon as the *Ostrea* bed. Fossil evidence and the lithological character of these beds seem to indicate shallow water origin.

Although the Kumage beds are intensely folded and overthrusted, the Kukinaga beds are only slightly tilted eastwards at small angles and cut by a number of strike faults. As already stated, the meridional direction of these faults governs that of the valleys in the southern part of the southern division. The geological age of the Kukinaga beds, which is estimated to be 100 m. thick between Masuda and Injô and in the southern division is, on palaeontological evidence, ascribed to the Burdigalian or the Lower Mizuho.

Kaminaka Beds. These beds, which comprise all the terrace deposits except those of the lowest abrasion benches, resting horizontally with pronounced unconformity on trachydolerite and the preceding beds, consist of gravels, sands, sandy clays, iron sands, and pumiceous and vitreous ash beds. The terrigenous materials of this group are all, either directly or indirectly, derived from the Kumage beds; that is, the gravel beds of this formation contain pebbles and boulders of rocks from the Kumage beds as do the conglomerates of the Kukinaga beds. For this reason, it is sometimes very difficult to distinguish the Kaminaka beds from the loose and soft conglomerate of the Kukinaga beds. The sands and gravels on the terraces and plateaus, which vary in thickness, pass into brown and reddish-brown sandy clays and black humus a few meters in total thickness. The sandy clays are always intercalated with pumiceous and vitreous ash beds that generally occur in single bands, usually 30 cm. and rarely as much as 3 m. in thickness, and rarely in two or three bands, each 30 cm. thick and separated by intervening sandy clays of about the same thickness. The pumiceous beds consist mostly of small grains of pumice, 3—10 mm. diameter, while the vitreous beds are minutely triturated transparent splinters of volcanic glass. Both these beds are always stained either yellow or buff colour by impregnations of iron oxide solutions from the sandy clays. The sands very

1) 武部, 2) 安城, 3) 犬城, 4) 増田, 5) 河内.

frequently contain an enormous quantity of iron sand, amounting at times to as much as 90 percent, for example at a place east of Sakai and also at Yokino.

The Kaminaka beds, resting on a highly denuded surface of the Kukinaga beds near Masuda, comprise massive yellow, white, and light-brown sands with occasional intercalations of gravels, is estimated to be as much as 100 m. in thickness. In this yellow sand exposed north of Masuda, I found several casts of marine mollusca. Similar thick sands and gravels, also well developed in the vicinity of Kaminaka, are cut by a number of faults with a throw of a few centimeters.

In a road-cutting 500 m. north of Sumiyoshi are exposed horizontally lying terrace deposits composed of a dark-gray sandy clay and a light-brown sand resting on a denuded surface of badly deformed Kumage beds. The terrace deposits, which are cut by faults with throws of less than a meter, yield in its lower part numbers of excellently preserved shells of marine mollusca, the genus *Ostrea* being particularly abundant, so that it is called the *Ostrea* bed, which according to Mr. S. NOMURA, contains also the following species : *Anomia cytaeum* GRAY, *Arca* sp. indet. *Cyclina sinensis* (GMELIN), *Gourmya coralia* (KIENER), *Ostrea rosacea* DESHAYES, *Ostrea* sp. (cf. *O. sinensis* GMELIN), *Paphia philippinarum* (ADAMS and REEVE), *Trapezium sublaevigatum* (LAMARCK), *Acmaea pygmaea* (DUNKER), *Batillaria multiformis* (LISCHKE), *Hemifusus tuba* (GMELIN), *Littorina souverbiana* GROSSE (?), *Nassarius hiradoensis* (PILSBRY), *Odostomia* sp., *Rapana bezoar* (LINNAEUS), *Theodoxus* (*Clinthon*) *sowerbianus* (RECLUZ), *Turbo granulatus* GMELIN.

According to the same writer, all these species are at present living in the sea adjacent to the island, although there is some doubt in this respect concerning *Ostrea* sp. (cf. *O. sinensis*), the most abundant form.

Besides the shell beds just mentioned may be found at places near the coast, at Nokan[1], Onasu[2], and Masuda, heaps of shells that are supposed to be shell mounds.

The Kaminaka beds are believed to be contemporaneous with the Kunigami gravel, judging from its stratigraphical position. That the Kaminaka beds were deposited in a shallow sea is indisputable, seeing that they contain the molluscs just enumerated. The Kunigami gravel on the other hand has so far yielded no fossils, the occurrence and distribution of the manganese nodules in it suggesting marine origin, at least in parts. If we may correlate the Kaminaka beds with the Kunigami gravel, almost the whole of Tane-ga-shima must have been drowned in the Pleistocene seas (Shikishima Period).

Since sediments contemporaneous with the Riukiu Limestone and the Shimajiri beds are lacking in this island, a prolonged land period must be supposed to have existed before the Kaminaka beds had been laid down on the Kumage and Kukinaga beds. The transgressing Pleistocene seas covered the land-surface of the Kumage and the Kukinaga beds, and cutting the successive terraces and after depositing the Kaminaka beds, periodically retreated.

The linear coasts on the west side of the island and the scarps that extend from Ôbirono to Tanowaki, and from Haruta to Nakayama, from Mitariyama to Yuku, and from Nishiyama to Sakai, suggest that a block movement occurred in this island either after the regression of the Pleistocene sea or after the upheaval of the land.

Following this tectonic disturbance came a fairly large positive shift of sea level in this island, when the lower courses of the valleys were drowned, while some of them were later filled with certain deposits. The wave-cut benches and the beach deposits that were formed during the submergence became exposed above sea level by a slight negative change of sea level.

Recent Deposits and Sand Dunes : As reef-building corals are now growing in the seas

1) 納官, 2) 女洲.

adjacent to the Ôsumi group, although their growth is not vigorous enough to build true coral reefs, such as may be seen in the islands south of the Tokara Strait, littoral deposits of the island contain a good many fragments of these reef-builders. Foraminifera are also abundant in the recent shore sands, *Amphistegina radiata* (FICHTEL and MOLL) and *Baculogypsina sphaerulata* (PARKER and JONES) being the most predominant species. It is worthy of note that the species *Calcarina spengleri* (LINNÉ) (=*Tinoporus baculatus* MONTFORT ?), so characteristic of the recent deposits in the islands south of the Tokara Strait, Taiwan, the South Sea Islands, etc., is absent from Tane-ga-shima. A great quantity of iron sand is contained in the shore sands in every part of the island, its content at Yokino and Ôgeri[1] being as much as 90 per cent.

Sand dunes composed of quartz and iron sand mixed with foramiferal test, etc., are well developed in places along the coasts. Creeping up the surface of the terraces, they are frequently as high as 80 m. On the surface of the 40 m. terrace at Annô, one finds horizontally laid cross-bedded sands, composed principally of tests of *Amphistegina radiata* (FICHTEL and MOLL), covering the sandstones and conglomerates of the Kukinaga beds. The coast near this locality being of cliff-type, no sand dunes are seen in the neighbourhood, the cross-bedded sands just mentioned being referable to dune sands rather than to the Kaminaka beds, owing to its lithological character being indistinguishable from that of the dune sands found south of Minato[2] on the northeast coast of the island.

Yaku-shima.

Geographical Situation and Topographical Features.

Yaku, lying at the southern extremity of the Ôsumi group in Lat. 30°28′—30°63′ N. and Long. 132°21′—130°39′ E., is nearly circular in outline with small indentations on the coast, its maximum diameter north to south being 27.5 km. It is almost entirely mountainous, with Miyanoura-dake[3] near the center of the island, rising to 1935.3 m., the highest elevation in the island as well as in all the regions lying between Honshû and Taiwan. Besides Miyanoura-dake are other lofty peaks, such as Nagata-dake[4] (1890 m.), Kuromi-dake[5] (1836 m.), Shichigo-dake[6] (1492 m.), Hasha-dake[7] (1259 m.), Wariishi-dake[8] (1410.2 m.), Motchomu-dake[9] (944 m.), Atago-dake[10] (1226 m.), Yoshida-dake[11] (1165 m.), Tsubokiri-dake[12] (1409.2 m.), Kuniwari-dake[13] (1328 m.), Odachi-dake[14] (1084 m.), Tachû-dake[15] (1511 m.), etc., scattered over the mountainous region. In the northwestern third of the whole extent of the coast of this island (i. e., from Shidoko[16] to Kuryû)[17], precipitous mountain sides drop straight into the sea from such heights as 1,000 m., while in the remaining two thirds, mountains with similar steep slopes are bordered by narrow dissected coastal terraces. The coastal terrace begins in the west from a place 2 km. north of Kuryû, and extends southwards with a height of 60 m. and a width of 200 m. Beyond the valley of the Kuryû River, the terrace may be traced far southwards, maintaining the same height and width as far as the village of Nakama[18], Along both sides of the river near Kuryû are developed narrow river terraces of nearly the same elevation. The terrace on the south coast from Nakama to Anbô[19] is 1 km. in average width, its inner edge being generally 100 m. above sea level, but sometimes attaining to about 200 m. as in the 8 km. stretch from Yudomari[20] to Haro[21]. Here the south slopes of Hasha-dake and Motchomu-dake rapidly fall away to the 200 m. elevation, whence the slope changes abruptly the upper part that is higher than the terrace by 100 m. inclining more or less suddenly, while its lower part does so very slowly. The same topography may be seen west of Anbô. The terrace on the east coast from Anbô to Tabukawa[22] is the broadest, the maximum width being 2.5 m., and differentiated in two or three steps, the upper being 200 m., the

1) 大花里, 2) 湊, 3) 宮ノ浦岳, 4) 永田岳, 5) 黒味岳, 6) 七五岳, 7) 破沙岳, 8) 割石岳, 9) 本富岳, 10) 愛宕岳, 11) 吉田岳, 12) 坪切岳, 13) 國割岳, 14) 尾立岳, 15) 太忠岳, 16) 志戸子, 17) 栗生, 18) 仲間, 19) 安房, 20) 湯泊, 21) 原, 22) 楮川.

middle 140 m., and the lower 80 m. in elevation, the lowest terrace being the broadest with a width of 1 km. On the northeast coast from Tabukawa to the Tomari[1] River, 2 km. northwest of Miyanoura[2], the lowest terrace continues with an average width of 1 km. The outer edges of the coastal terraces usually end off in vertical cliffs of various heights. As just stated, this island, in the distribution of its coastal terraces, is asymetrical, but around all the coasts, both the base of the mountain slopes along the northwest coast and that of the cliffs bordering the outer edges of the coastal terraces, are uniformly surrounded by low narrow abrasion benches, 5—10 m. above sea level, as seen in Tane and elsewhere.

All the larger rivers of this island originating in Miyanoura-dake and neighbouring lofty mountains diverge radially and cut deep gorges in the mountainous regions. The Miyanoura, Anbô, and Kuryû Rivers suddenly broaden out in their lower courses, while both the Nagata and Issô Rivers have flood plains that suddenly broaden in their lower courses. These evidences, coupled with the occurrence of numerous indentations on the coasts, suggest that submergence of land occurred in this island at a late geological age. Mr G. IMAMURA (Lit. 43) has called attention to the invariable presence of a cascade in the lower course of every river close to the elevated shore line. This fact and the occurrence of raised abrasion benches show that the above-mentioned land-submergence was followed by a slight emergence of land. The latest geological history of Yaku-shima agrees with that of the other islands of the Riukiu Curve.

Stratigraphy.

In my short stay of only a week in the island I walked around it, using only the roads along the coast, never entering its interior, excepting that I once crossed the 800 m. pass west of Kuniwari-dake in a trip from Nagata[3] to Kuryû. For this reason I am not qualified to offer any adequate information regarding the geology of the island. As Messrs. K. NISHIWADA (Lit. 4) and G. IMAMURA (Lit. 43) have already stated, the island is composed almost wholly of porphyritic granite with large phenocrysts of plagioclase 6—7 cm. long and 2—3 cm. broad, surrounded along the coasts by a narrow belt of sedimentary rocks. The sedimentary formation consists largely of black clay slates (partly metamorphosed into spotted slates and hornfelses by contact action of the porphyritic granite), with subordinate fine grained greenish-gray sandstones and black conglomerate with small round pebbles of sandstones and slates (contact-metamorphosed and found only in one locality east of Issô). This formation is developed as the bed rock of all the terraces mentioned as also in the mountainous region near the coasts, from a little north of Segiri[4] to Yudomari and from Anbô to the upper end of the Issô River flood plain. The strata exposed everywhere in this island are intensely folded and faulted with a general strike of N. 20°—30° E., regardless of the direction of the boundary between the porphyritic granite and the sedimentary formation, with very steep and vertical dips, either eastward or westward. Of the jointings developed in the formation, a vertical one with a N. 70° W. trend is predominant. Though the sedimentary formation has so far yielded no fossils and despite the uncertain geological age, I should like here to correlate it with the Palaeozoic formations developed in the islands south of the Tokara Strait for the reason already stated in the foregoing chapter (Stratigraphy of the Riukiu Islands).

No bed that is believed to be equivalent to either the Kumage, Kukinaga, Shimajiri, Yaeyama, or Miyara beds exists in this island, although terrace deposits a few meters thick and unmistakably contemporaneous with the Kaminaka beds are well developed, covering the coastal terraces. The terrace deposits consist mainly of round pebbles and boulders of granite and the sedimentary rocks derived from the mountains and the foundations of the terraces, the diameter of the boulders some-

1) 泊川, 2) 宮ノ浦, 3) 永田, 4) 瀬切.

times attaining to a size of 7 m. or more. The upper part of the terrace above the 100 m. level extending from Yudomari to Haro just mentioned, is covered with granite-boulders of enormous size which may be regarded as fanglomerate formed along the foot of the mountains. The gravel beds are generally interbedded in the upper part by one or two layers of pumiceous and vitreous ashes, buff in colour, and 30—40 cm. thick, as in the case of the Kaminaka beds of Tane-ga-shima. A terrace deposit that crops out in the cliff along the south bank of the Anbô River is composed of gravels, white quartz sands, a single thin bed of pumiceous tuff, and a brown sandy clay in ascending order. These white sands are occasionally interbedded iron sands. In the village of Oseda[1] and its vicinity, a white pumiceous bed, 2 or 3 m. thick, is developed. Mr. G. IMAMURA (Lit. 43) also found some huge blocks of pumice, about 1 m. in diameter, scattered on the terrace south of Tabukawa. As to the cause of the presence of these huge blocks of pumice, his opinion is that they were cast up by the sea by virtue of their large size, and not brought aerially.

1) 小瀬田.

Appendix.

Peculiar Distribution of Venomous Snakes in the Riukiu Islands and Its Relation to the Geological History of the Islands.

1) Distribution of Venomous Snakes in the Riukiu Islands.

It is well known that extremely venomous snakes, the *Habu* in Japanese, infest the Riukiu Islands. According to Dr. M. MAKI (Lit. 41), the *Habu* in the Riukiu Islands are classified as follows:

Trimeresurus flavoviridis flavoviridis (HALLOWELL) (*Habu*)
Trimeresurus flavoviridis tokarensis (NAGAI) (*Tokara-habu*)
Trimeresurus okinavensis BOULENGER (*Hime-habu*)
Trimeresurus elegans (GRAY) (*Sakishima-habu*)

The distribution of the poisonous serpents in the islands is very peculiar. The *Trimeresurus flavoviridis* and *Trimeresurus okinavensis* are endemic to Amami and Toku in the Ôshima group; to Okinawa, Kouri, Yagaji, Ie, Sesoko, Yabuji, Henza, Taka, Ichi, and Hamahiga in the Okinawa subgroup; to Iheya, Noho, and Gushichâ in the Iheya subgroup; to Kume, Wô, Ôha, Tonaki, Tokashiki, Kuro, Jifushi, Gusuku, Fukase, and Mae in the Kerama subgroup, while *Trimeresurus flavoviridis tokarensis* is endemic to Takara and Kotakara in the Tokara group; and *Trimeresurus elegans* to Ishigaki, Iriomote, Kobama, Taketomi and Kuro in the Yaeyama group.

Besides these trimeresurine snakes, another venomous snake, the *Agkistrodon halys blomhoffi* (BOIE) (*Mamushi* in Japanese) has been recorded from Okinawa and Ishigaki (Lit. 41). This is a snake that has its habitat also in Honshû, Shikoku, Kyûshû (including the Ôsumi group of the Riukiu Islands), Hokkaidô, all in Japan proper, and in Taiwan.

No venomous snakes are found in the following Riukiu islands:

All the islands of the Tokara group, excluding Takara and Kotakara; Okierabu, and Yoron in the Ôshima group; the two Tori-shima (one of which lies west of Toku and the other north of Kume); Tsuken, Kudaka, Ukibaru, Minami (Fê)-ukibaru, the Kê Is., Aguni in the Okinawa subgroup; Izena, Yanoshita, and Yanaha in the Iheya subgroup; Yukan, Koba, Zamami, Aka, Amuro, Akenashiki, Kahi, Geruma, Fukashi, and Wô in the Kerama subgroup; all the islands of the Miyako group; Yonaguni, Hatoma, Aragusuku-kanji, Aragusuku-shimoji, and Hateruma in the Yaeyama group; and all the islands of the Ôagari group.

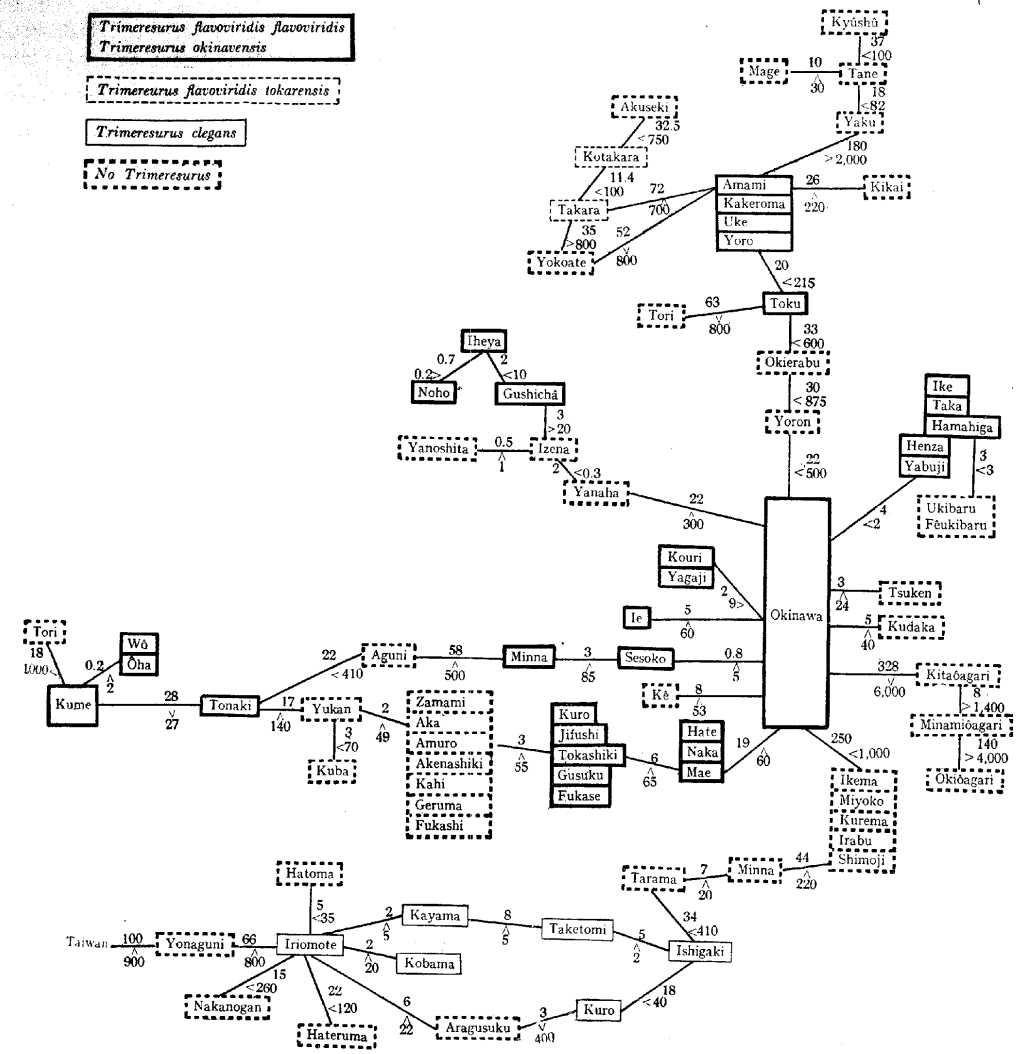
Zoögeographers include the Ôsumi group into the Palaearctic region and all the islands forming the Okinawa-Ôshima and the Sakishima group into the Oriental region, and draw the "WATASE line" that crosses the Tokara Strait as the boundary of the two regions.

The trimeresurine ophidian fauna is restricted to the following localities, besides the Riukiu Islands, viz., South China, the Philippines, the East Indies, India, and the northern regions of Oceania, none being found in the regions north of the WATASE line (Lit. 40).

The distribution of venomous snakes in the Riukiu Islands is indeed curious, presenting an interesting problem in zoögeography. According to Dr. O. ABEL (Lit. 27), reptiles recognized as true ophidia first came to existence in the Cretaceous, while the venomous snake did so in the Miocene. An inspection of the distribution of the trimeresurine ophidian fauna in the world leads one to infer that the *Trimeresurus* now living in the Riukiu Islands originally crossed over from Taiwan by a land bridge and then dispersed throughout the islands. And, in order to explain the reason for a certain species being confined to a certain region, we are compelled to assume that, (1) the three species and a variety of the genus *Trimeresurus* enumerated in the foregoing must have differentiated

Chart Showing the Distribution of Venomous Snakes in the Riukiu Islands.

(N. B. The numbers indicate the distance and the depth between the islands in kilometer (upper) and in meter (lower) respectively).



from one or more species of the genus; (2) after this differentiation had been accomplished, the lands which are now the various islands, with their respective snake faunas, were separated from one another by deep and wide seas, and have remained so ever since; (3) all the islands that are now inhabited by one and the same species or variety were once connected by dry land. If these assumptions are admissible, all the islands in the Okinawa-Ôshima group now inhabited by *Trimeresurus flavoviridis flavoviridis* and *Trimeresurus okinavensis* must have been at one time connected to one another, forming a large island; likewise all the island in the Yaeyama group now inhabited by *Trimeresurus elegans* forming another large island, as also Takara and Kotakara now inhabited by *Trimeresurus flavoviridis tokarensis* forming still another island.

From the distribution of the trimeresurine snakes in the Okinawa-Ôshima group, it is obvious

that the climatic conditions of the islands has nothing to do with it. There is no striking climatic difference between the Ôsumi group and Amami. The average annual minimum air temperature of Tane, ±11.1°C, is the same as that of Amami. The southen limit of snow-fall in the Riukiu Islands lies at present in the Tokara group, owing to the presence of lofty mountains (1,000 m.) in that group.

As stated elsewhere, the geology of the islands now inhabited by the venomous snakes does not differ from that of the islands that are not inhabited by them, which is to say that these snakes thrive quite well regardless of the substratum on which they exist. Animal and plant life in the Riukiu Islands differ but little, if any, in the different islands. The venomous snakes feed on wild rats and mice and other small animals, all of which are found in every island of the Riukiu Archipelago. All doubts as whether or not the venomous snakes in the islands not inhabited by them now were exterminated by man will be dispelled by the knowledge that the authorities of Okinawa and Kagoshima Prefectures, who have for years been trying every possible means of ridding the islands of these snake pests, have not obtained results in any way commensurate with their efforts.

2) Migration of the Venomous Snakes and the Land Stages of the Riukiu Islands.

As to the age of immigration of the trimeresurine snakes from Taiwan to the Riukiu Islands by a land bridge, it was either in the post-Shimajiri or post-Riukiu stage. If I take the post-Shimajiri stage as the age, the immigrants could have dispersed throughout the Riukiu Islands, but not beyond the WATASE line, seeing that, according to the accepted view, in this period a broad water body, the Tokara Strait, would have prevented any such northward migration.

Further, in the Riukiu stage, these reptiles survived only in the higher parts of Takara, Kotakara, Amami, Toku, Okierabu, Okinawa, Kume, Iheya, Tonaki, Tokashiki, Mae, Yukan, Kuba, Ishigaki, Kobama, and Iriomote, because all the other islands and the lower parts of those islands just enumerated were drowned in the sea.

In the post-Riukiu stage, they again dispersed into the large islands that newly formed in this stage, as already mentioned.

In the Kunigami stage, land-submergence on a large scale occurred in the Riukiu Islands, when the venomous snakes survived only in Takara, Kotakara, Amami, Toku, Okinawa, Iheya, Kume, Tonaki, Tokashiki, Mae, Ishigaki, Kobama, and Iriomote, as the other islands had sunk under the sea.

In post-Kunigami stage, the snakes that survived in Kume migrated to Wô and Ôha, and those in Okinawa to Ie, Sesoko, Kouri, Yagaji, Wô, Yabuji, Henza, Taka, Ichi, Hamahiga, those in Ishigaki to Kuro and Taketomi, those in Iheya to Noho and Gushichâ, those in Tokashiki to Fukase, Jifushi, Gusuku, and Kuro now that they were all connected to one another.

In the latest submergence following the post-Kunigami stage, all the islands of the Riukiu Islands separated from one another as we find them at present, while in the latest slight emergence immediately following the preceding subsidence, Ukibaru, Minami (Fê)-ukibaru, Minna and the Kê Is. near Okinawa, first rose above the sea. These small islets never had any land connection with the other islands.

If the differentiation of species and varieties of the genus *Trimeresurus* occurred during the post-Riukiu stage, then the peculiar distribution of the *Trimeresurus* in the Riukiu Islands may be explained as has been done in the foregoing.

If we take the post-Riukiu stage as the age of the first immigration in question, this distribution of *Trimeresurus* in the islands may also be explained on the ground that the differentiation

of the species and variety of the genus occurred in the Kunigami stage, in which the land had periodically enlarged in area.

As already stated, *Agkistrodon hays blomhoffi* lives in all the Japanese Islands (excluding Sakhalin), Korea, and China (Lit. 41). Though the distribution of the species seems to be in contradiction of the theory of the WATASE line, the species found in Okinawa may be considered as having migrated from Taiwan, the same species in the Ôsumi group (Tane, Mage, and Yaku) from China, passing through Korea and Kyûshû.

Wild boars (*Sus leucomystax* TEMMINCK) live in Okinawa, Amami, Toku, Ishigaki, and Iriomote, but not in the other islands of the Riukiu group; that is, they are found only in islands inhabited by trimeresurine snakes. This peculiar distribution of wild boars may be explained in the same way as in the case of the trimeresurine snakes, although the former distribution is more restricted than that of the latter. This explanation receives additional support from the fact that beasts in small islands are easily exterminated by man, whereas to rid even a small island of trimeresurine snakes is almost an impossibility.

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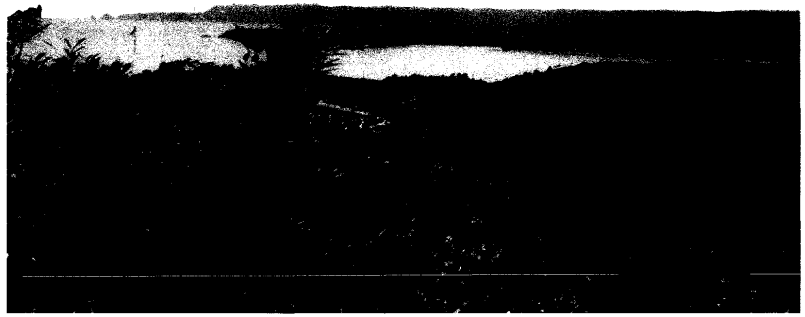

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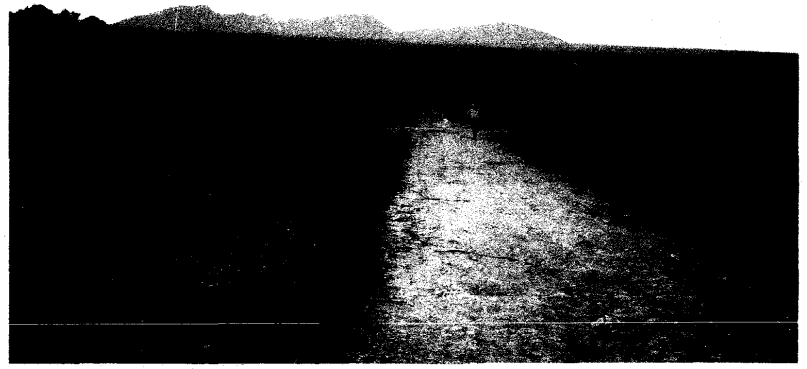

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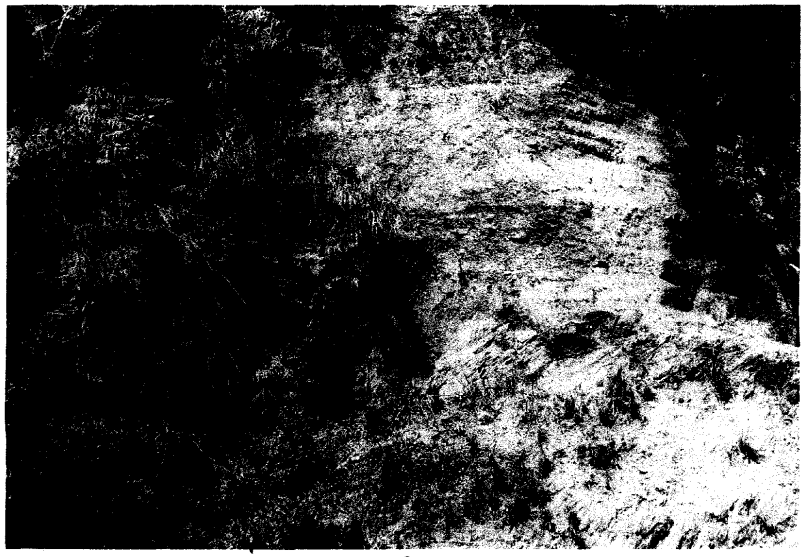

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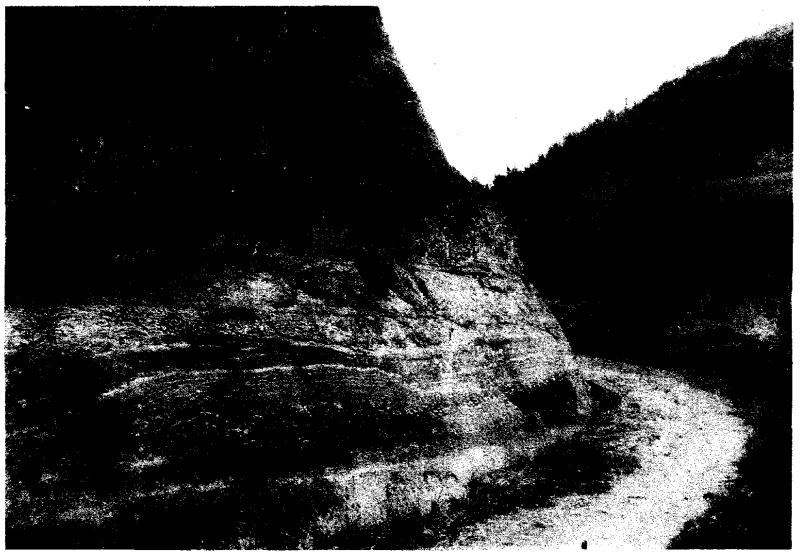

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S. Hanzawa photo.

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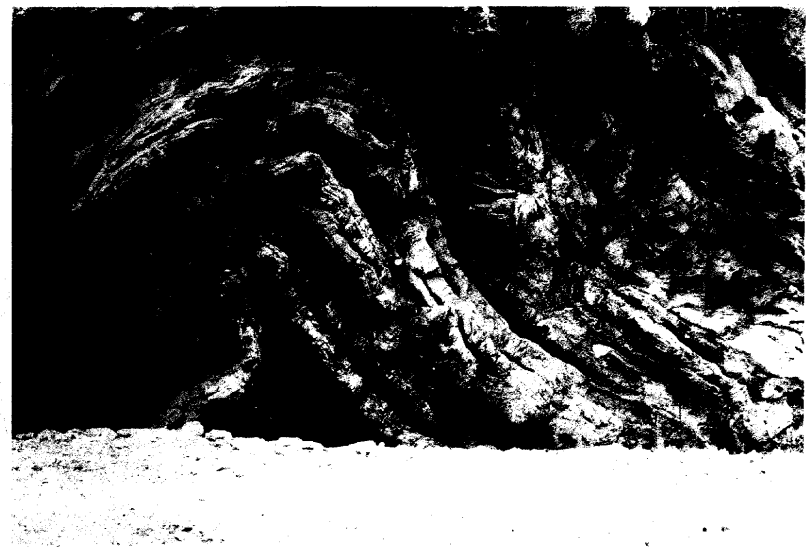

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S. Hanzawa photo.

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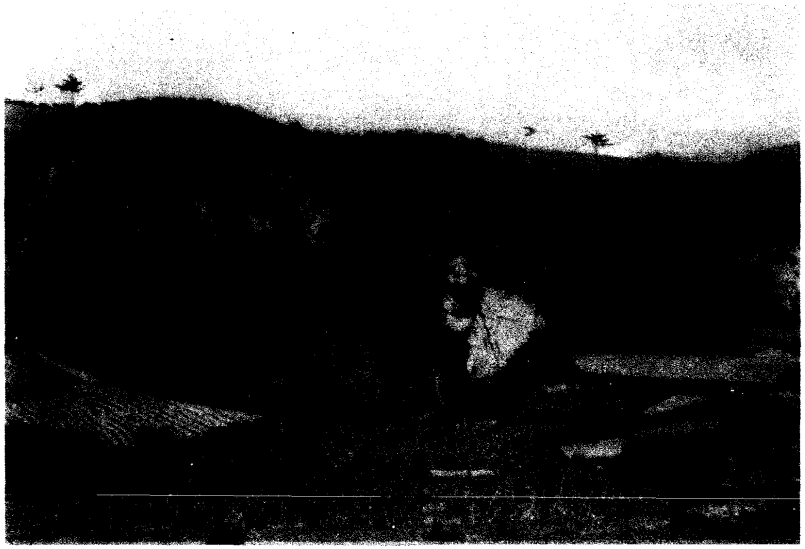

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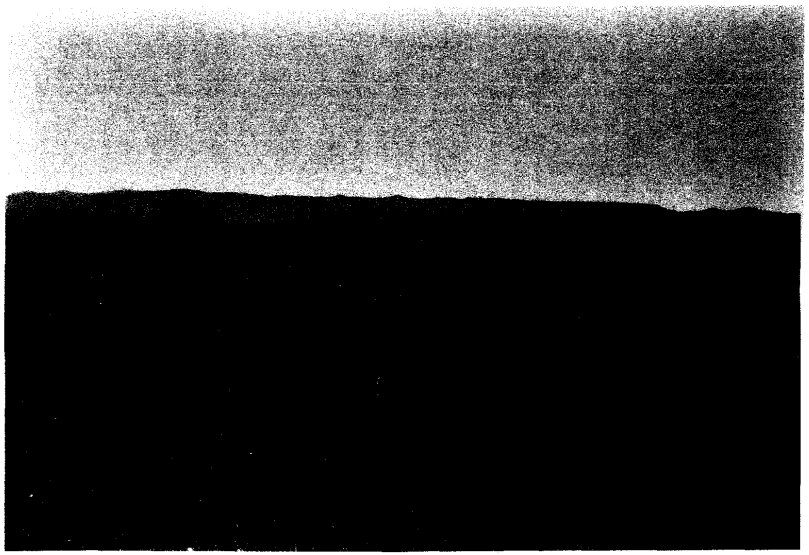

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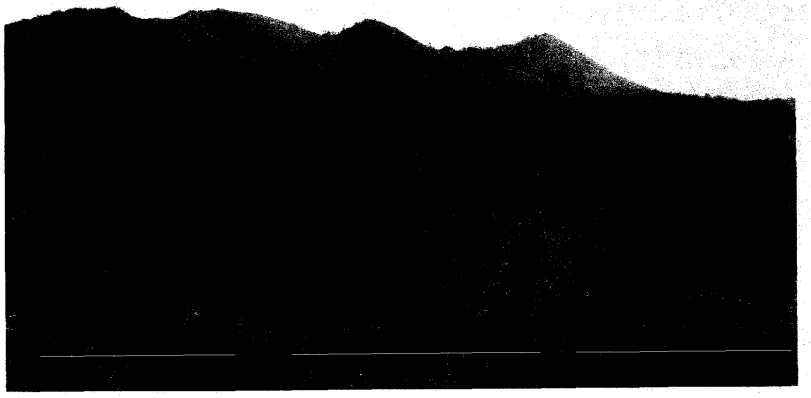

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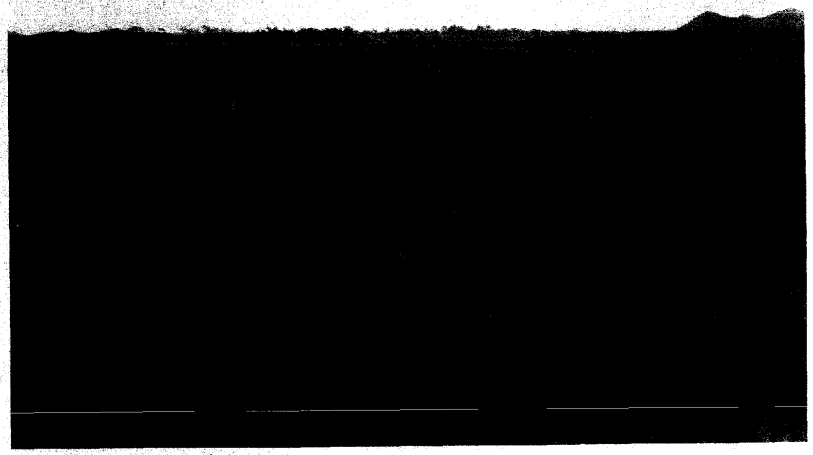

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S. Hanzawa photo.

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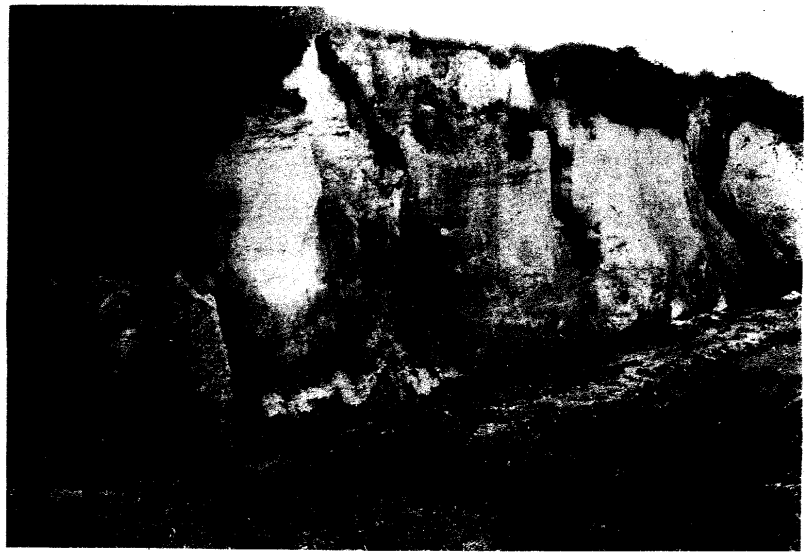

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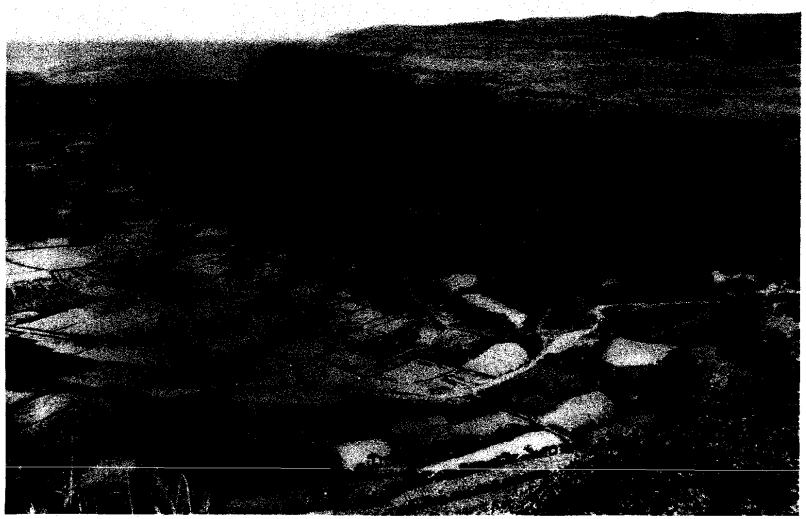

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S. Hanzawa photo.

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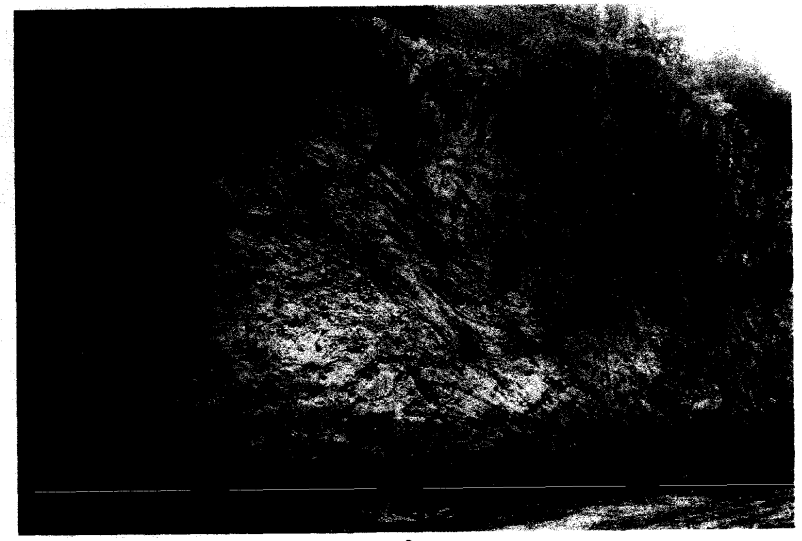

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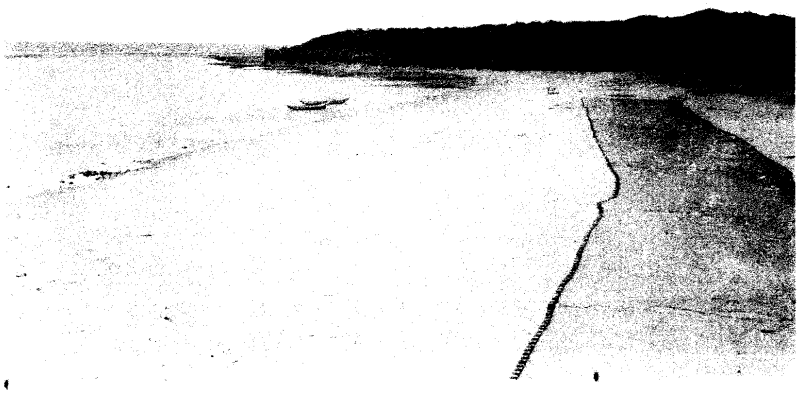

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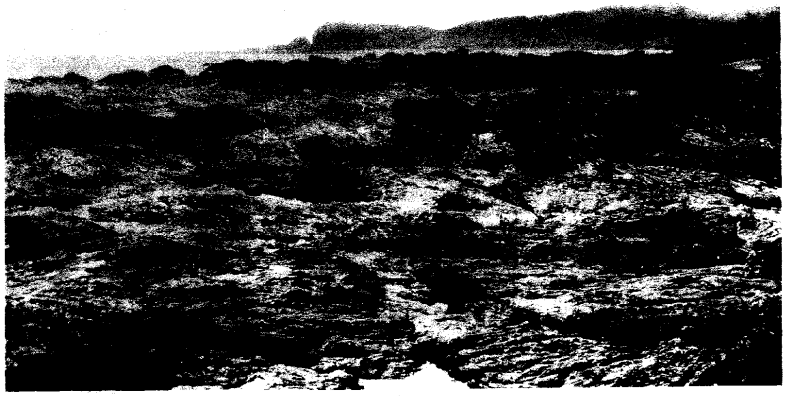

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Fig. 1. Toku. A dissected 80 m. terrace of Nishiakina with Intafu-dake in the distance.

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Fig. 4. Toku. A 40 m. terrace 1 km. northeast of San with Sansontsuji-dake in the background. The terrace is covered with a thick gravel bed containing numerous huge granite boulders (Kunigami gravel).

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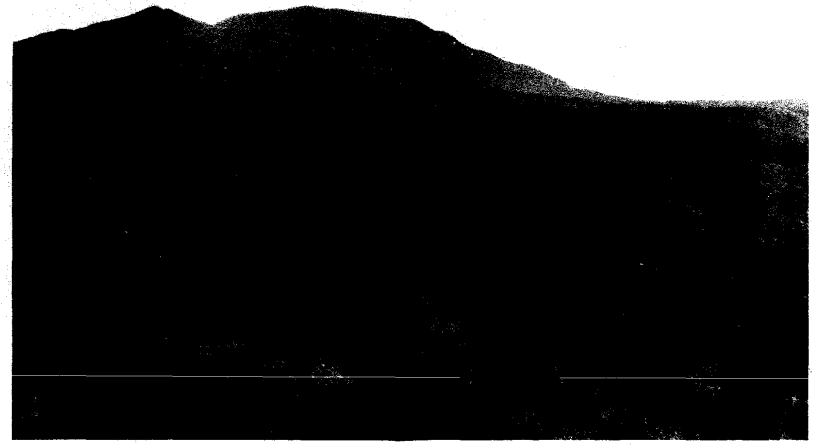

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Fig. 1. Kume. A distant view of Uegusuku-dake (left) and Ara-dake (right) across an 80 m. terrace of Riukiu limestone overlain by Kunigami gravel. View east from a little west of Ôharu.

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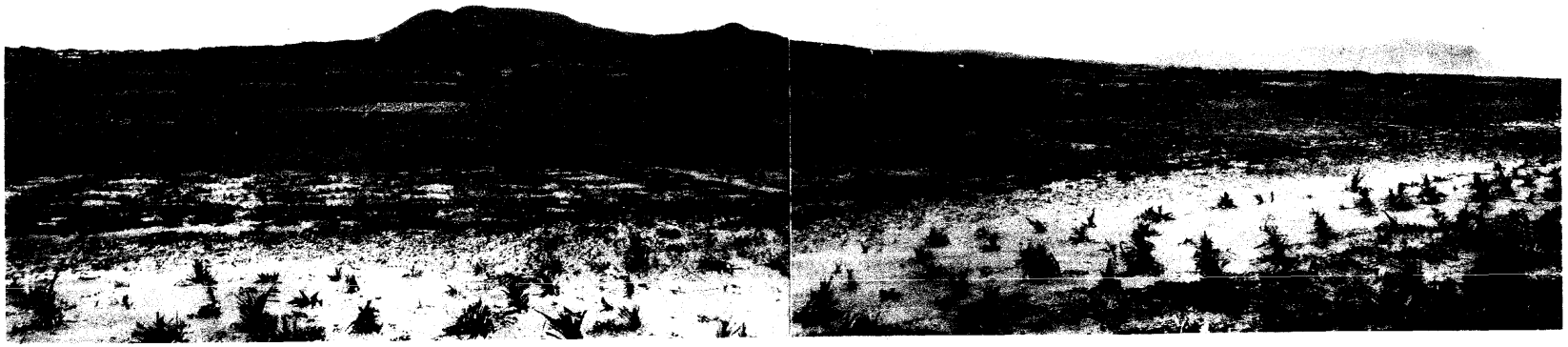

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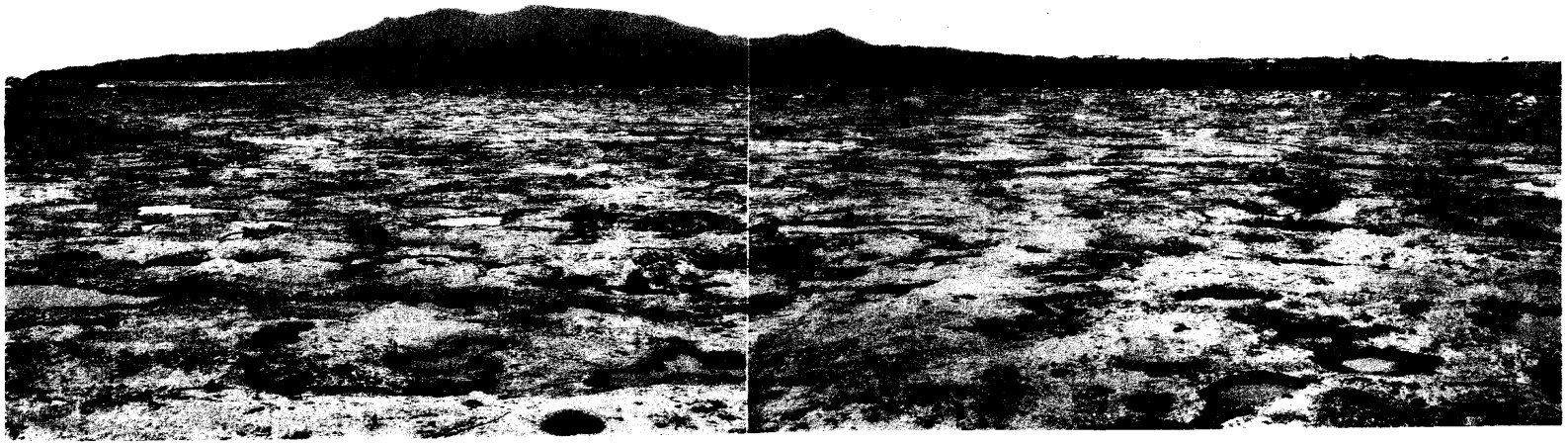

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Fig. 1. Kume. Wô-jima of andesite (background, right), Ôha-jima of Riukiu limestone (partly hidden behined Wô-jima, at its left), and two small Riukiu limestone islets (background, center and right) north of Ôha-jima. View northeast from a little east of the village of Tomari.

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S. Hanzawa photo.

Fig. 1. Yonaguni. Urabu-dake and a 100 m. terrace. View southeast from the Shimanaka plateau.

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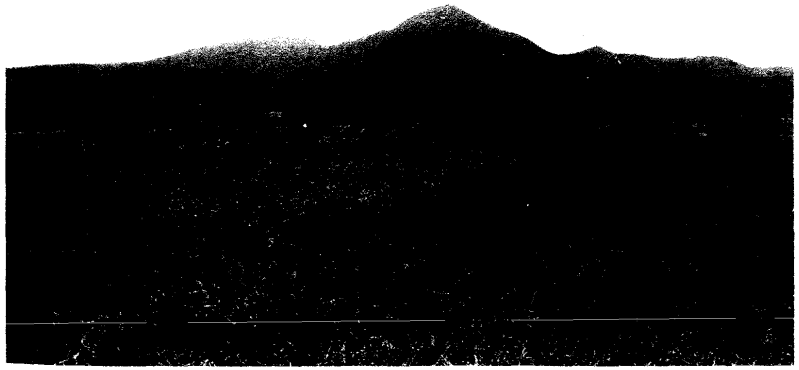

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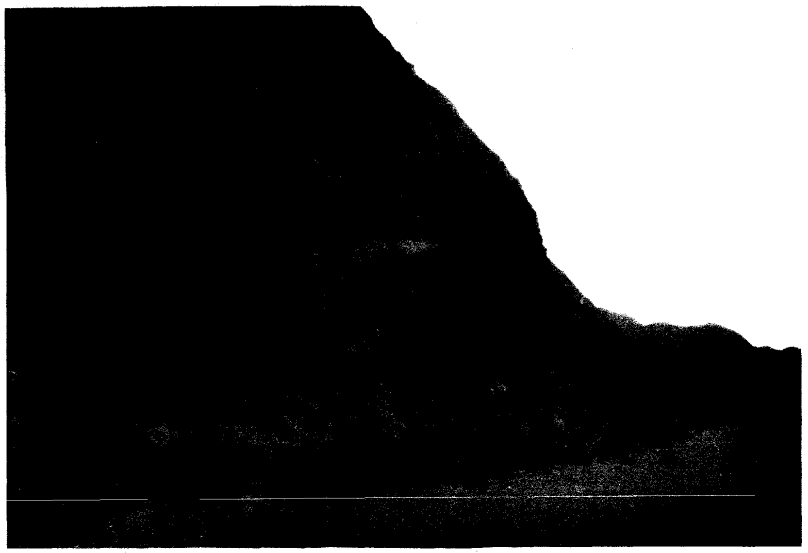

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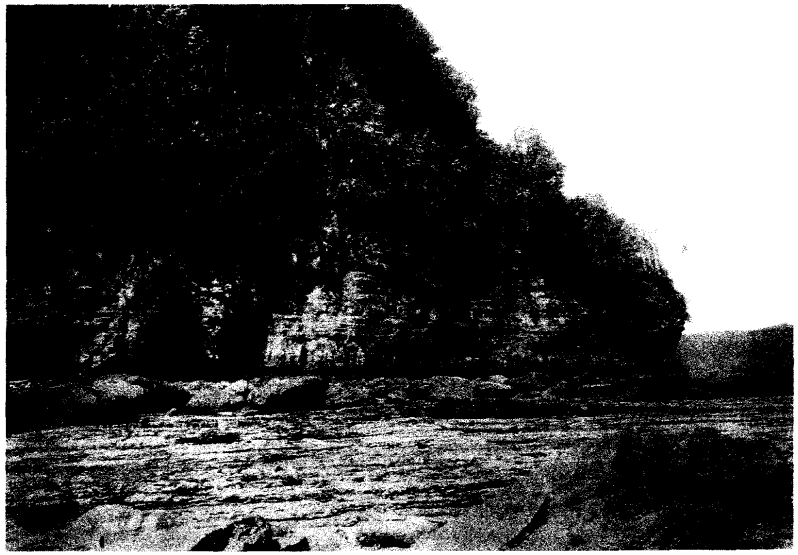

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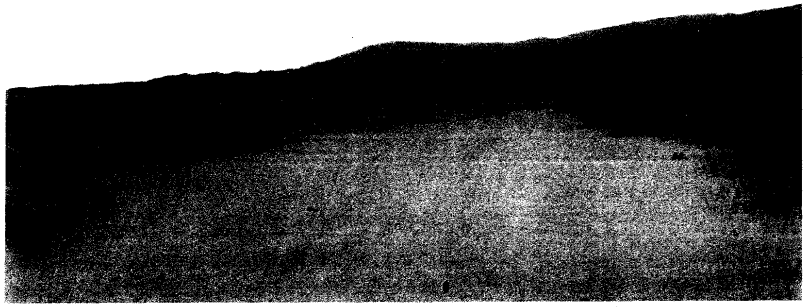

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S. Hanzawa photo.

Fig. 1. Ishigaki. An 80 m. terrace of Riukiu limestone south of Nosoko and the backbone ridge of the Ibaruma Peninsula. View north from Fukai.

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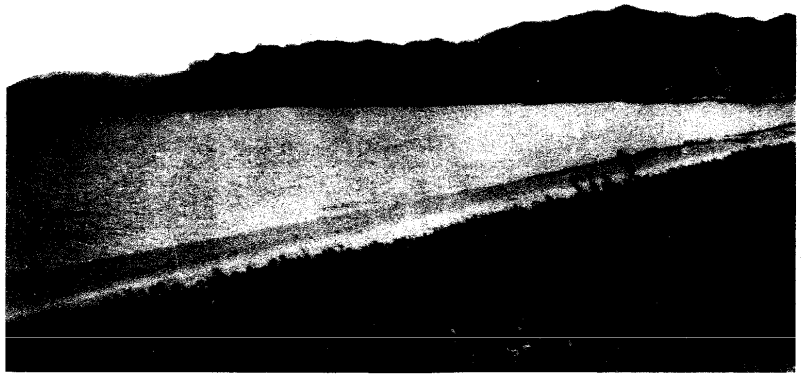

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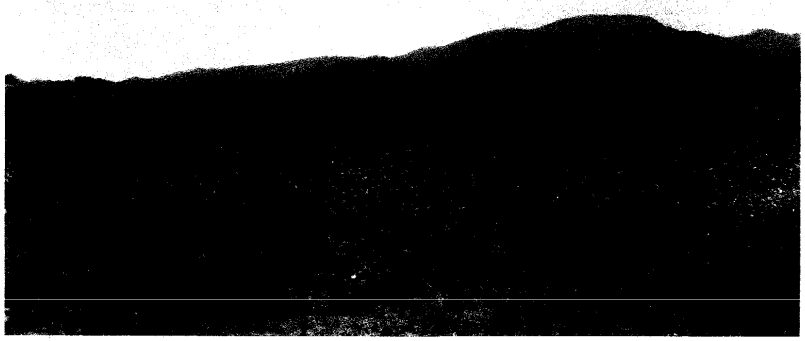

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Fig. 1. Tane. Thin-bedded shales and a moderately thick sandstone of Kumage beds in a road-cutting a little north of Kunigami.

Fig. 2. Tane. Contorted thin-bedded shales of Kumage beds in a sea cliff 1 km. northeast of Hirayama.

Fig. 3. Tane. Crush-breccia in a road-cutting a little north of Haruta.

Fig. 4. Tane. Slightly inclined sandstones and conglomerates of the Kukinaga beds overlain by a thin horizontal terrace gravel of Kaminaka beds forming a sea cliff east of Annô.

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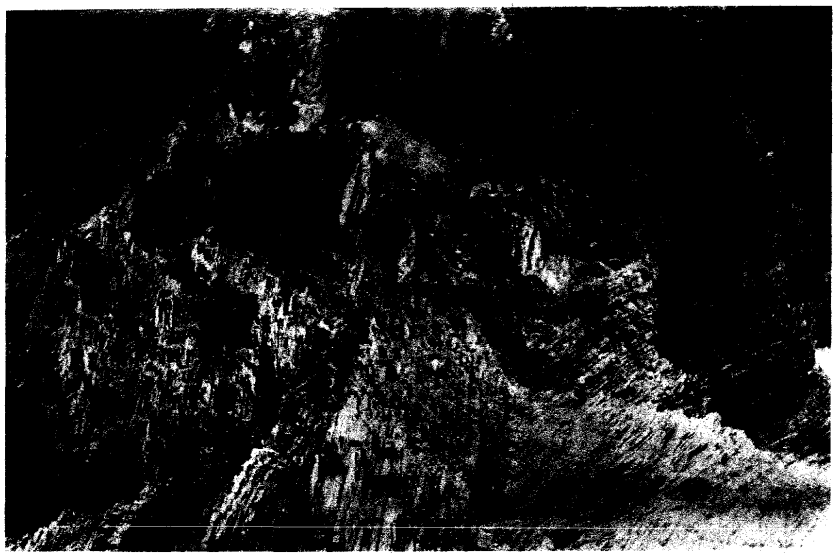

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Fig. 1. Tane. Kaminaka beds building a terrace 40 m. above sea level in a road-cutting, south of Takénokô.

Fig. 2. Tane. A part of the fault scarp extending from Ôbirono to Ishidô. Views north across a terrace from the northeast of Nakame, Nishino-omote.

Fig. 3. Yaku. An abrasion bench built up of vertical slates, 1 km. west of Oseda.

Fig. 4. Yaku. A mountain slope built up of porphyritic granite and hornfels. View northwest from a little south of Segiri.

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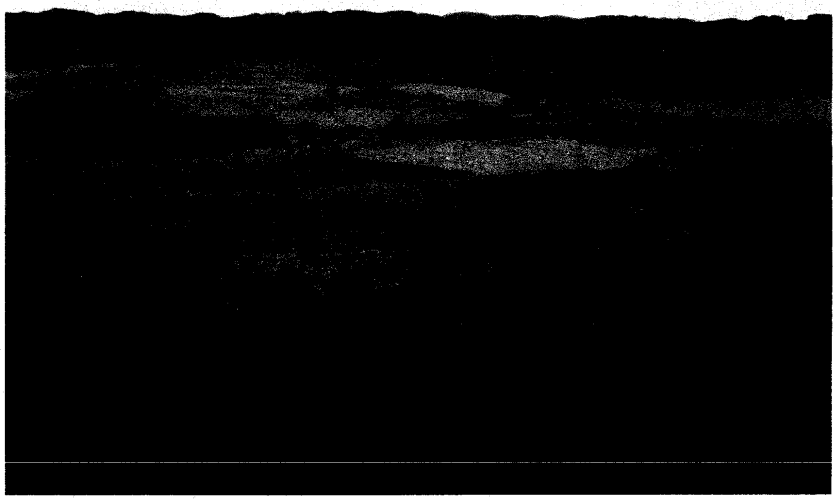

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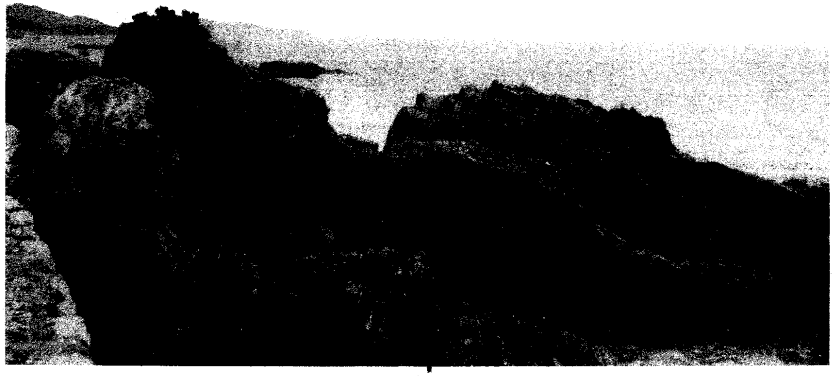

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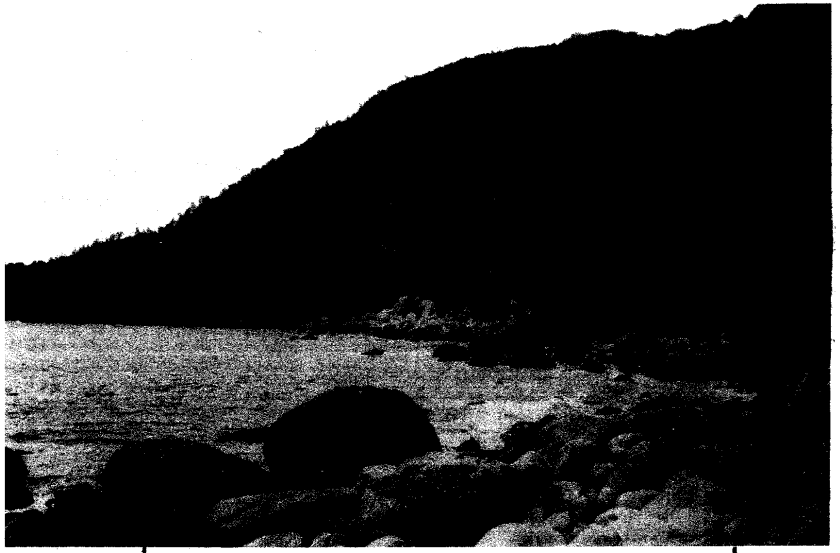

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GEOLOGICAL MAP OF TANE-GA-SHIMA

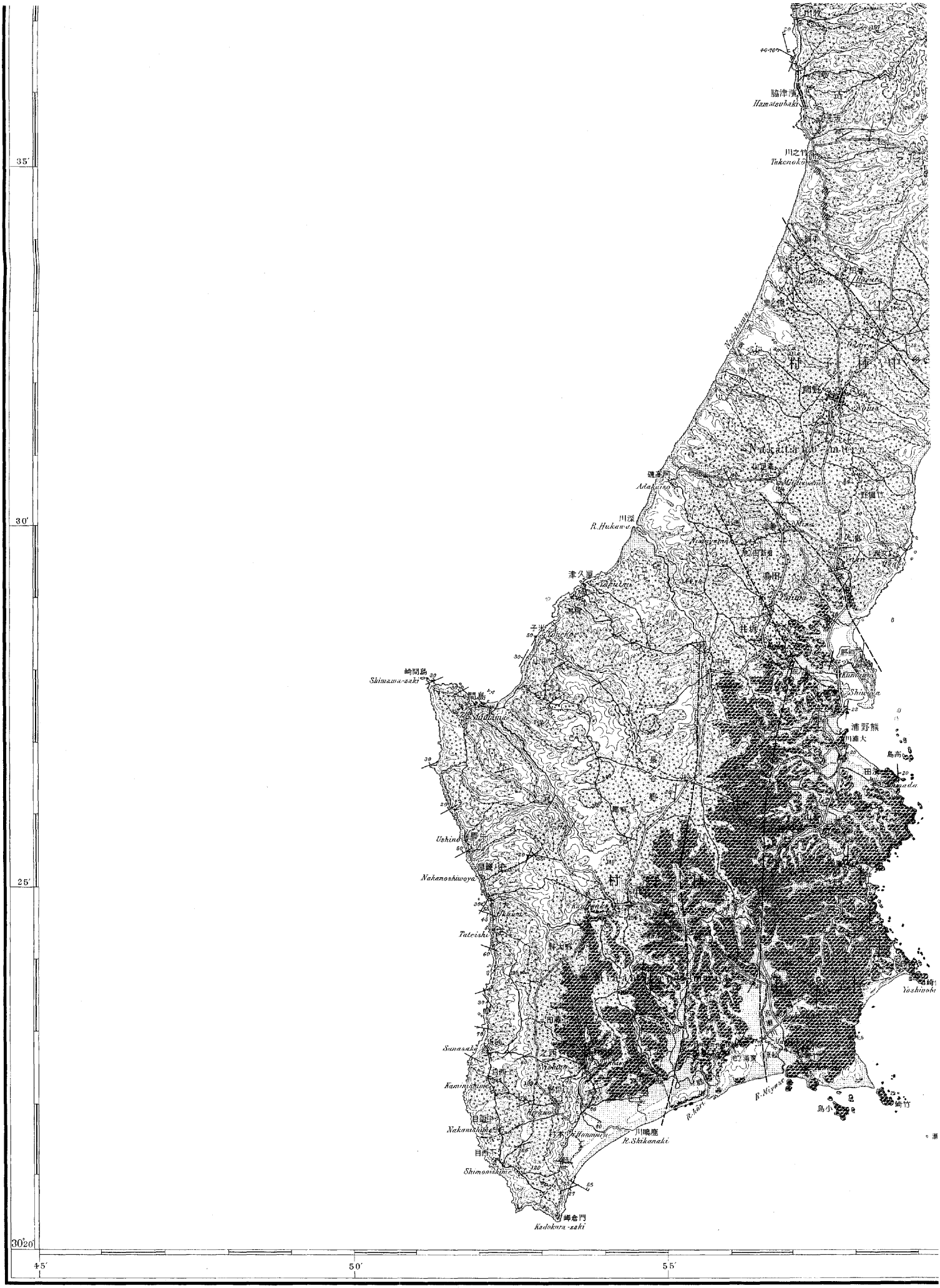
Recent Sand and Gravel
Sand Dune
Kamisaka Group
Enkimaga Group
Kumage Group
Trachydolerite
Strike and Dip
Anticlinal Axis
Strike of Vertical Beds
Horizontal Bed
Inclined Joints
Vertical Joints
Contorted beds (Sign at right angles to trend of folds)
ss Sandstone
sh Shale
Fossils
Fossil Locality

Drawn by Fusao Yamada in 1934.
Engraved by Kokashi Otsuki in 1934.

Scale 1:100,000

Science Reports of the Tôhoku Imperial University, Ser. II (Geology),
Vol. XVII, 1934. Geological Maps of the Riukiu Islands by SHÔSHIRÔ HANZAWA

GEOLOGICAL MAP OF TANE-GA-SHIMA



Drawn by Fusao Yamada in 1934.
Engraved by Kokudô Ôtsuki in 1934.

Scale 1:100,000

Km 2 1 0 2 4

Sheet V.

Recent Sand and Gravel

Sand Dune

Kaminaka Group

Kukinaga Group

Kumage Group

Trachydolerite

Strike and Dip

Anticlinal Axis

Strike of Vertical Beds

Horizontal Bed

Inclined Joints

Vertical Joints

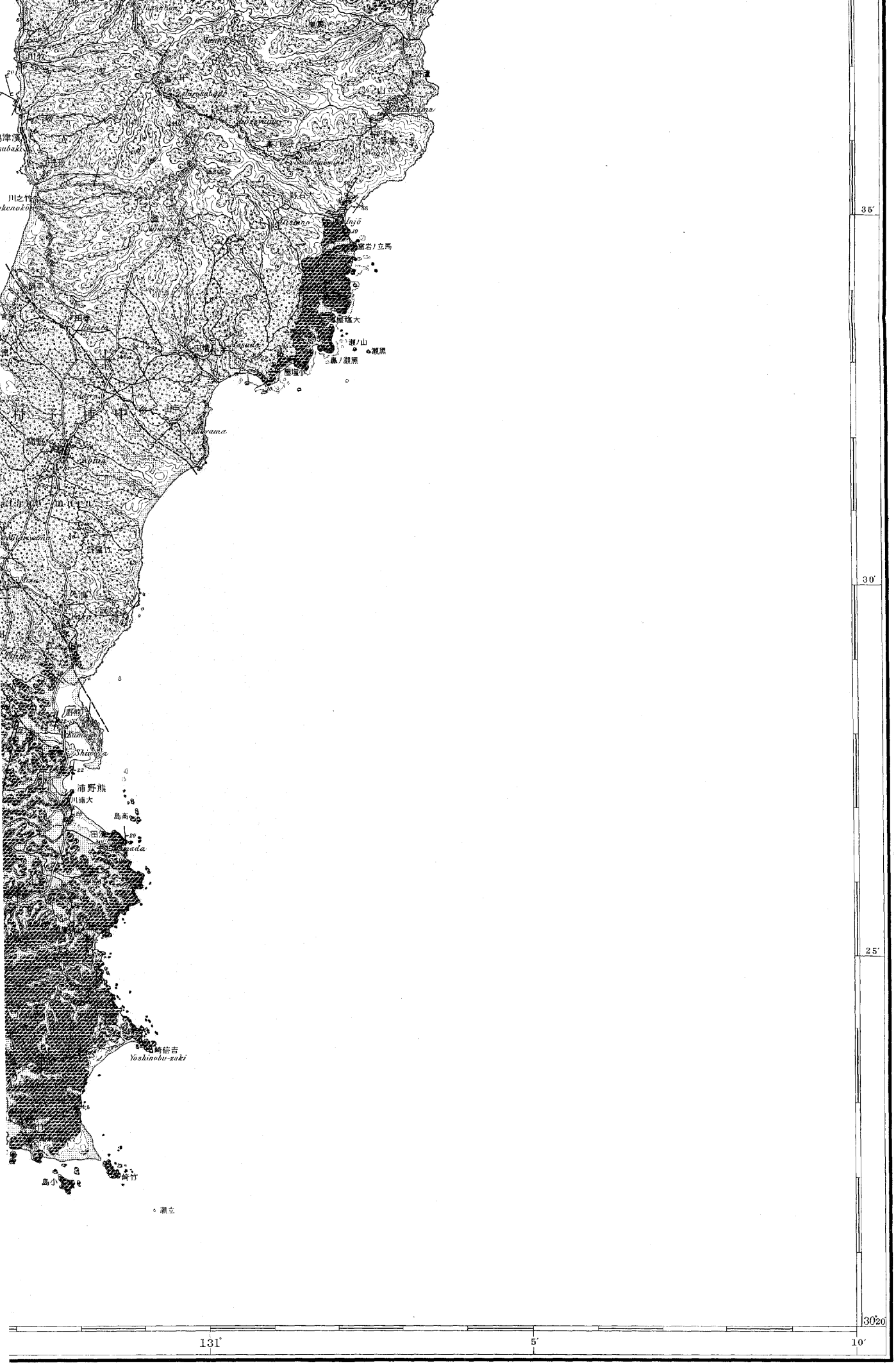
Contorted beds
(Sign at right angles to trend of folds)

ss Sandstone

sh Shale

Fault

Fassil Locality

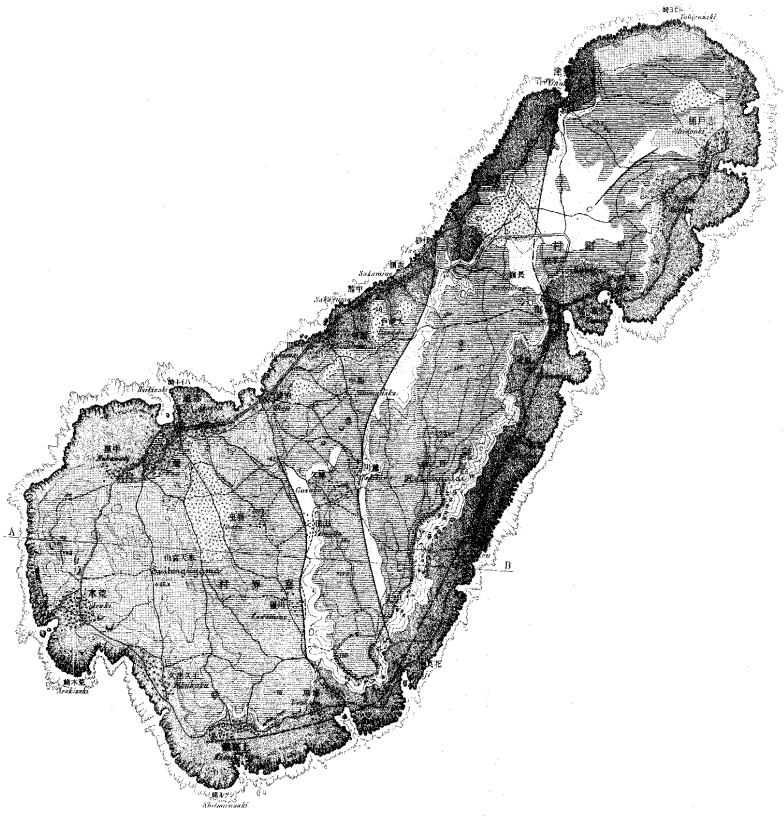


Scale 1:100,000

Science Reports of the Tôhoku Imperial University, Ser. II (Geology),
Vol. XVII, 1934, Geological Maps of the Riukiu Islands by SHÔSHIRÔ HANZAWA

GEOLOGICAL MAP OF OKIERÀBU-JIMA

GEOLOGICAL MAP OF KIKAI-JIMA



Recent Sand and Gravel

Raised Beach Deposits
Raised Coral Reef

Sand Dune

Kunigami Gravel

Riukiu Limestone

Shimajiri Group

Palaeozoic Formation

Porphyrite

Tonalite

Strike and Dip

Fault

Fossil Locality

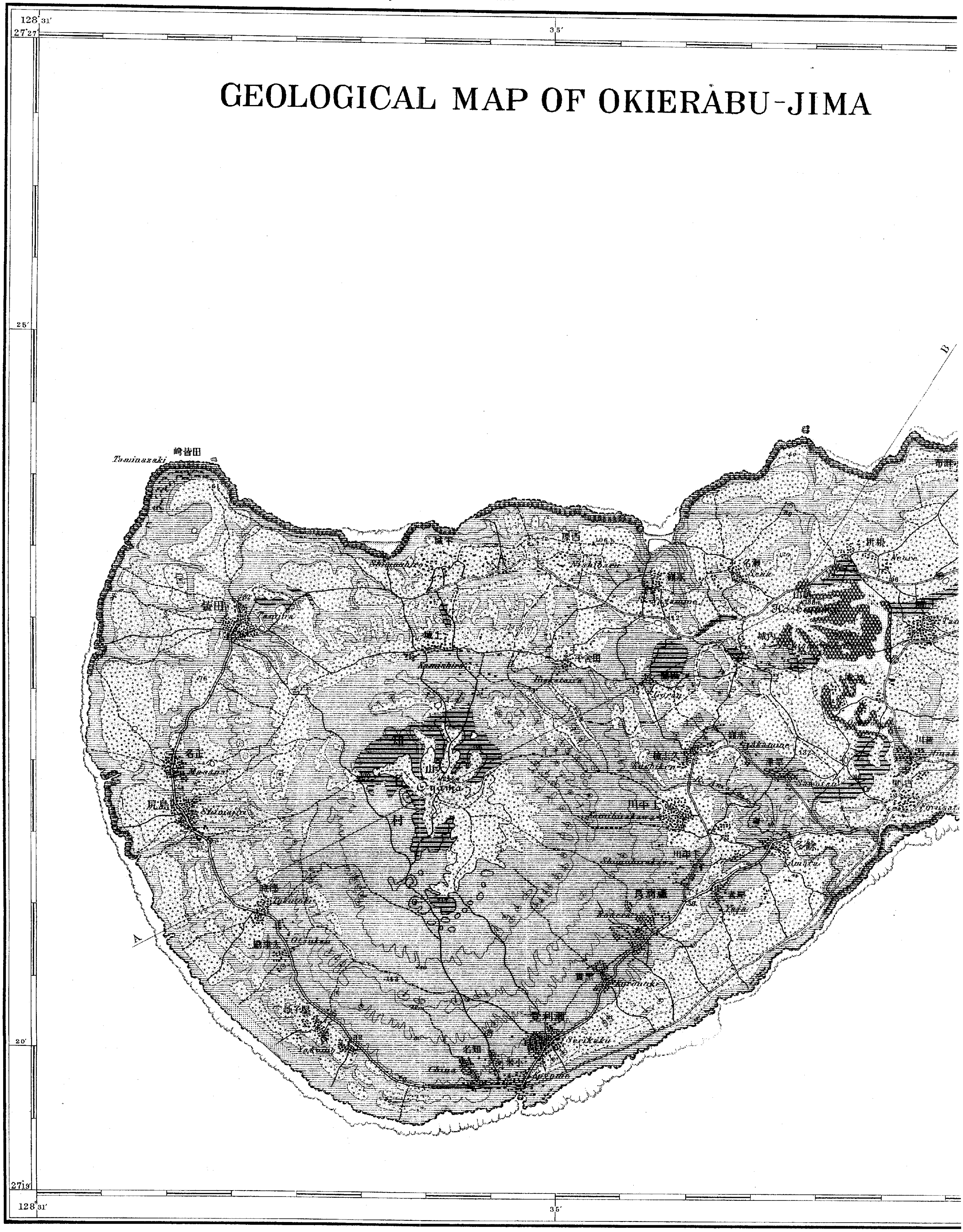
Drawn by Fusan Yamada in 1933.
Engraved by Kokadô Ôtsuki in 1933.

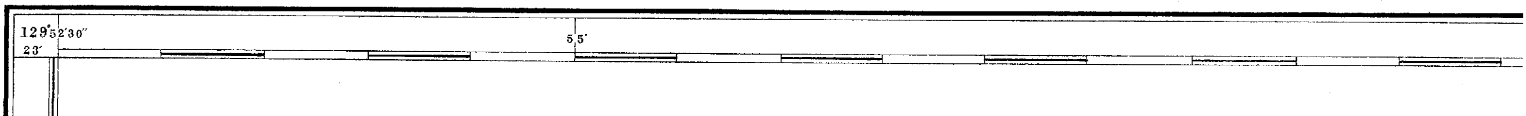
Scale 1:50,000

Contours 40 metres Vertical Interval

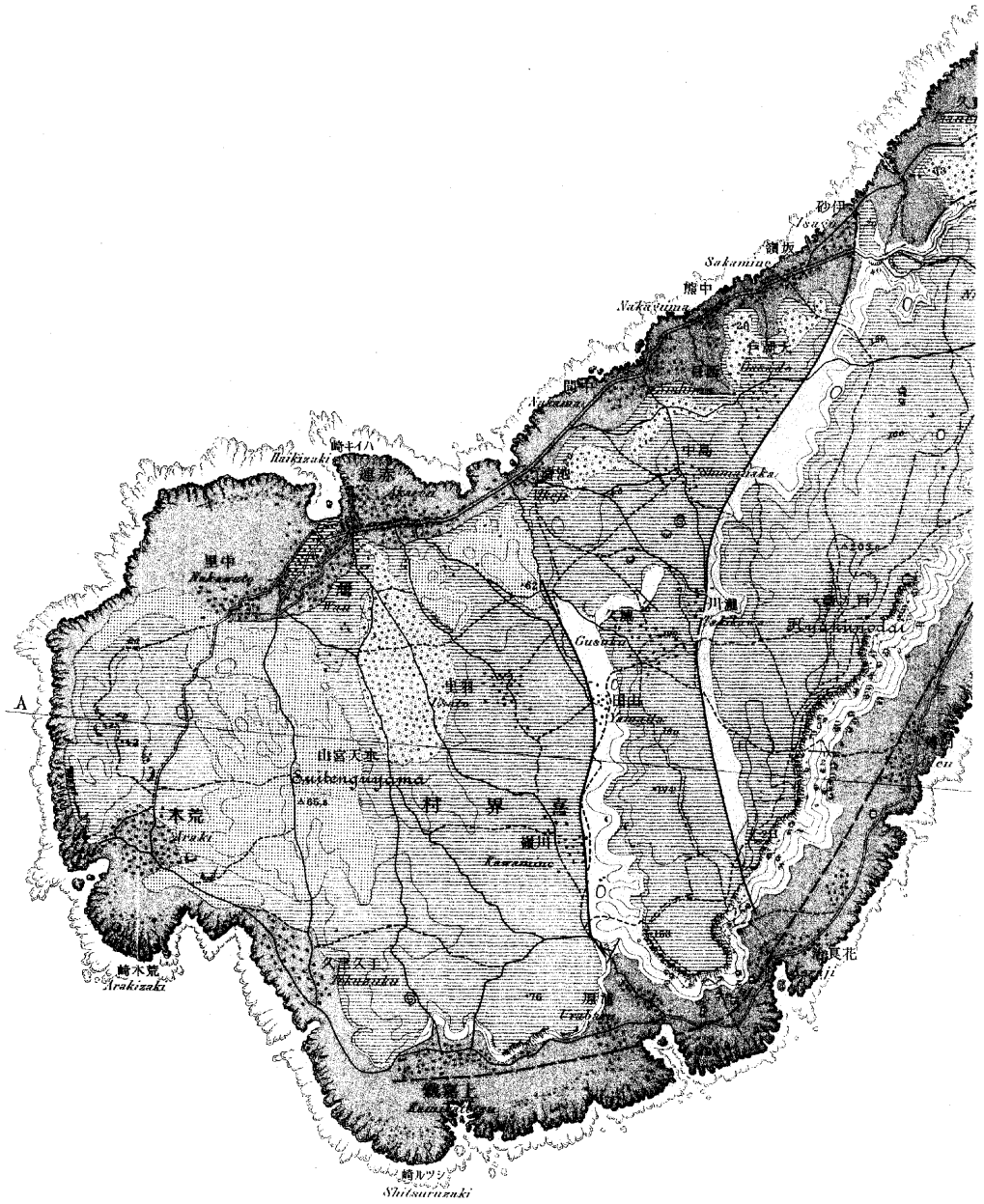
Science Reports of the Tôhoku Imperial University, Ser. II (Geology),
Vol. XVII, 1934, Geological Maps of the Riukiu Islands by Shôshirô Hanzawa

GEOLOGICAL MAP OF OKIERABU-JIMA





GEOLOGICAL MAP OF KIKAI-JIMA



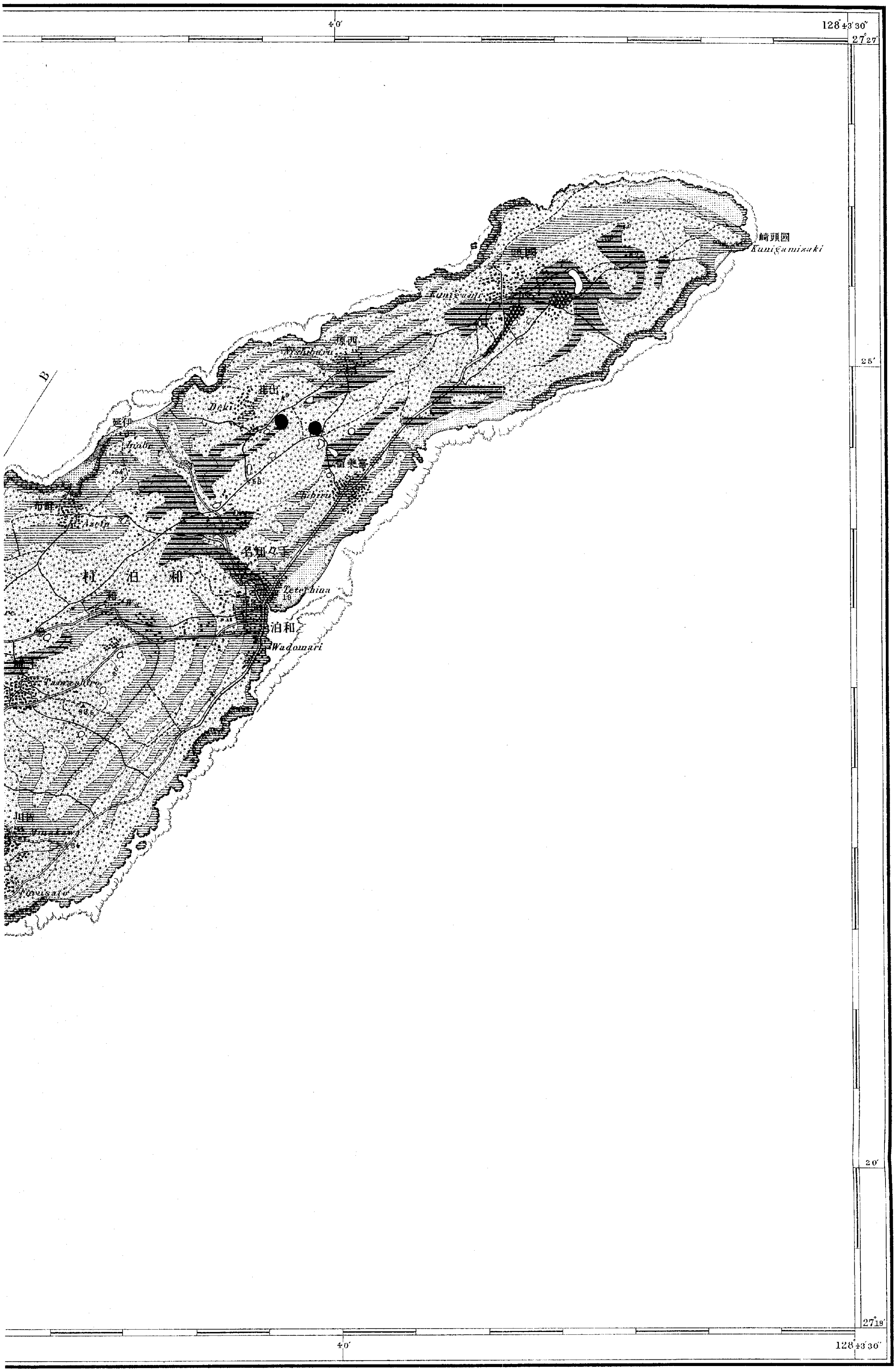
Drawn by Fusao Yamada in 1933.
Engraved by Kokudō Ōtsuki in 1933.

Scale 1: 50,000

1000m 500 0 1000 2000

Contours 40 meters Vertical Interval

Sheet I.



Recent Sand and Gravel

Raised Beach Deposits
Raised Coral Reef

Sand Dune

Kunigami Gravel

Riukiu Limestone

Shimajiri Group

Palaeozoic Formation

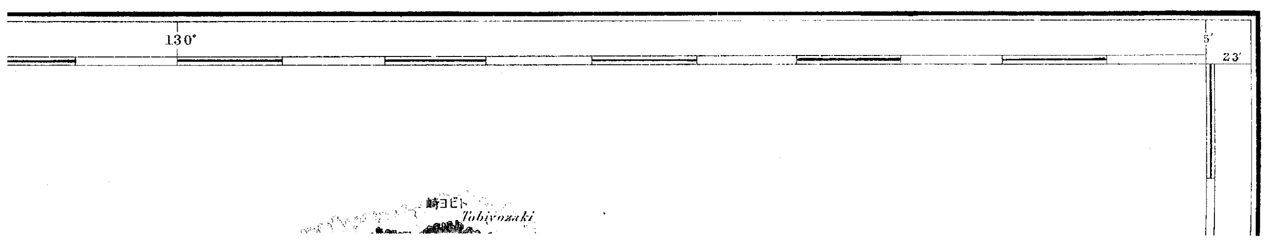
Porphyrite

Tonalite

Strike and Dip

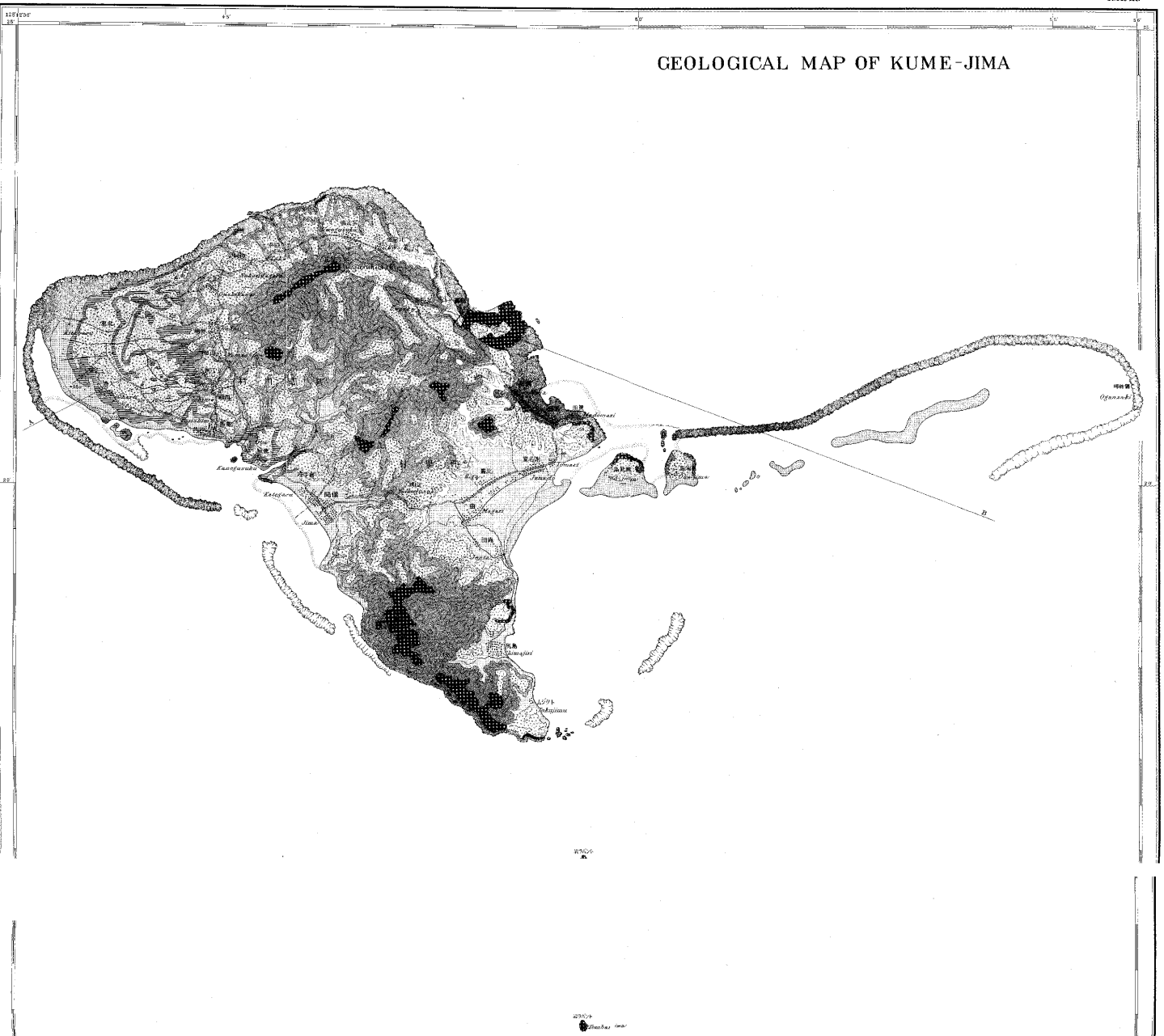
Fault

Fossil Locality



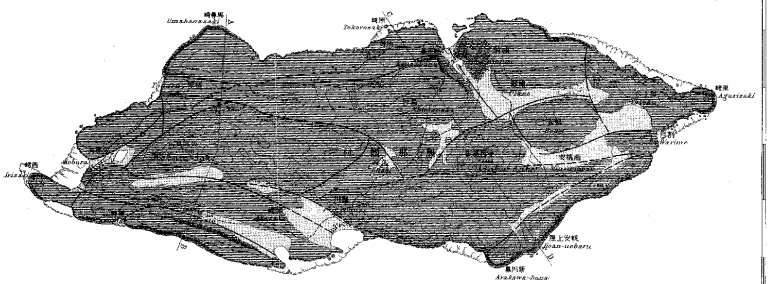

27°19'
40'
128°45'30"
130°
5'
23'
20'
28°
15'30"
130°
5'
B
Scale 1:50,000
0 2000 3000 4000m
meters Vertical Interval

GEOLOGICAL MAP OF KUME-JIMA

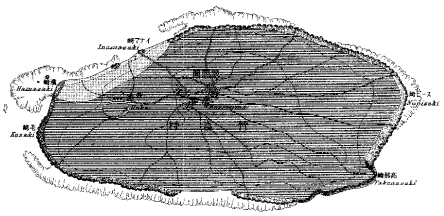


Recent Sand and Gravel
Raised Coral Reef
Sand Dune
Kunigami Gravel
Riukiu limestone
Andesite
Andesitic Agglomerate
Shimajiri Group
Yaeyama Coal Bearing Group
Strike and Dip
Fault
Fossil Locality

GEOLOGICAL MAP OF YONAGUNI-JIMA



GEOLOGICAL MAP OF HATERUMA-JIMA

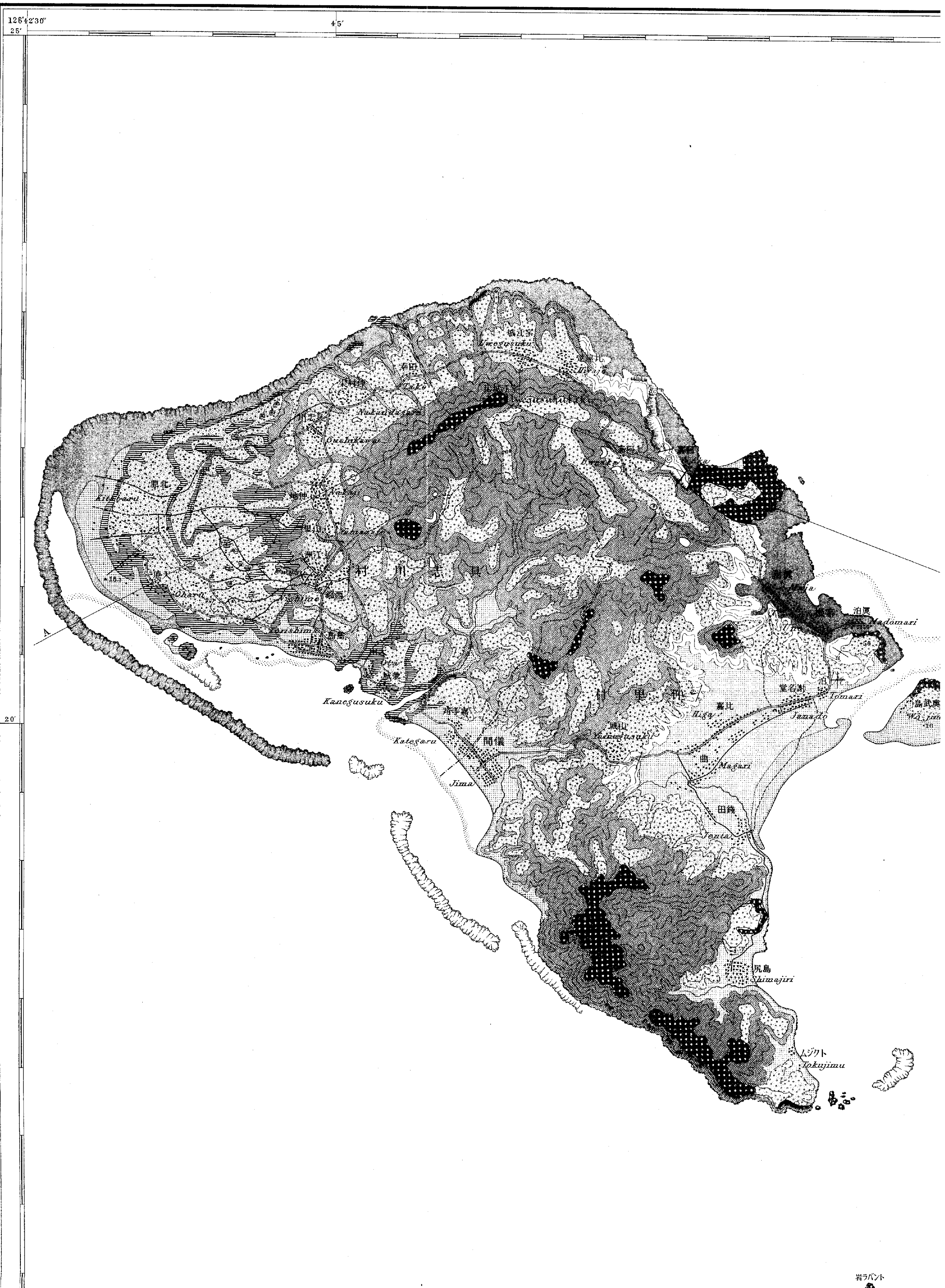


Drawn by Fusao Yasuda in 1933.
Engraved by Kokuô Ôtaki in 1933.

Scale 1:50,000

Contours 40 meters Vertical Interv

Science Reports of the Tôhoku Imperial University, Ser. II (Geology),
Vol. XVII, 1934, Geological Maps of the Riukiu Islands by SHÔSHIRÔ HANZAWA

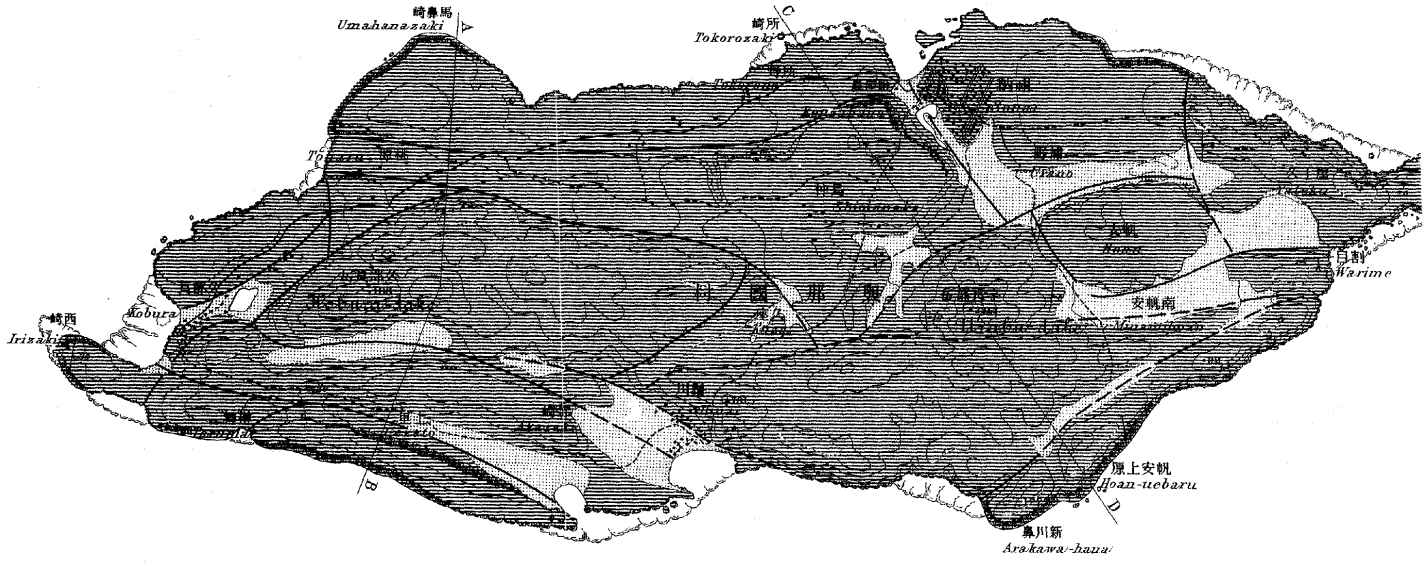


岩ラバント
Tombau

26'15"
126°42'30"
45'

55'30"
30'30"
123°

GEOLOGICAL MAP OF YONAGUNI-JIMA



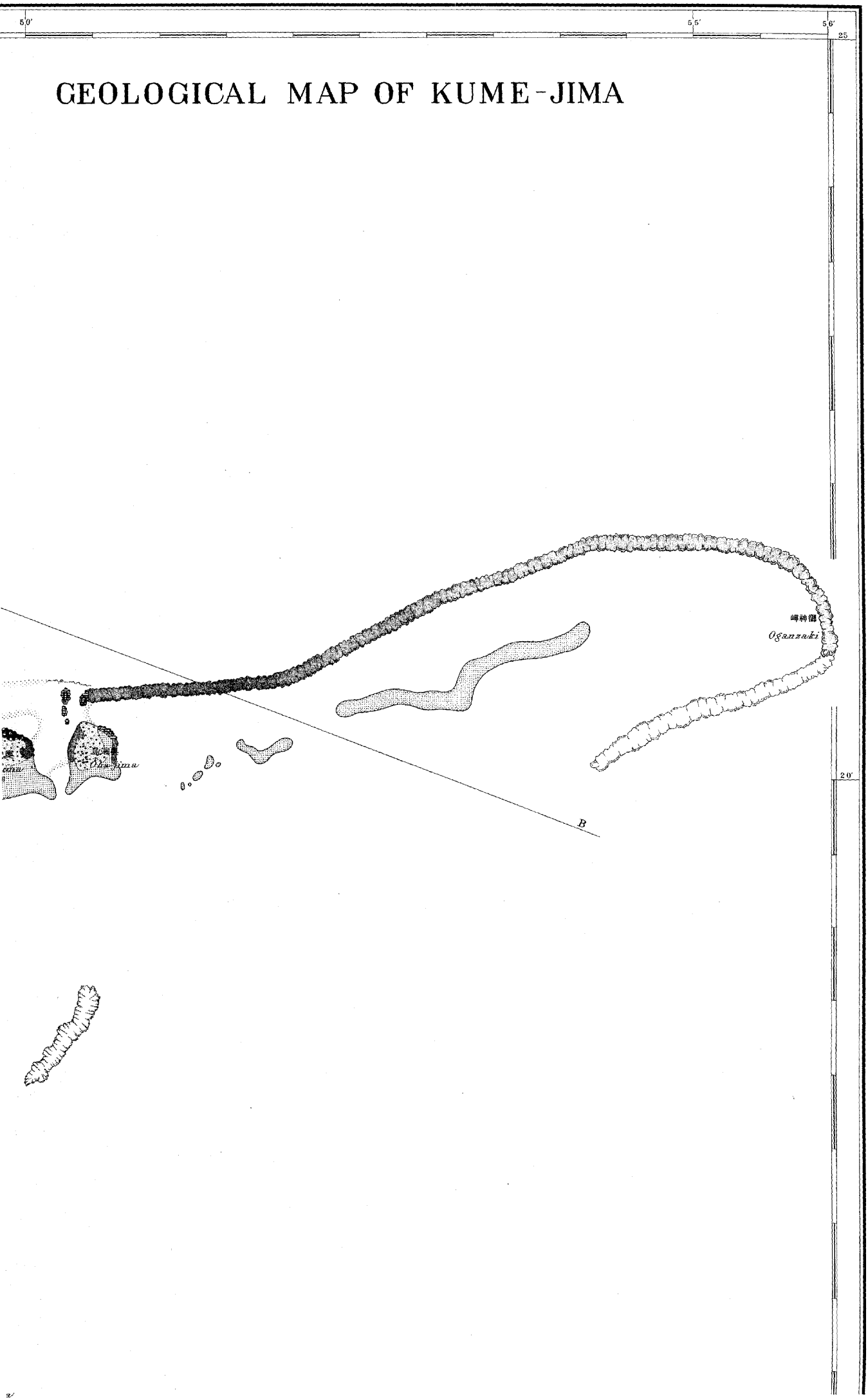
30'
25'
24°
24'30"
55'30"
123°

Drawn by Fusao Yamada in 1933.
Engraved by Kokudô Ôtsuki in 1933.

Scale 1:50,000
1000m 500 0 1000 2000

Contours 40 meters Vertical interv

GEOLOGICAL MAP OF KUME-JIMA



Recent Sand and Gravel

Raised Coral Reef

Sand Dune

Kunigami Gravel

Riukiu Limestone

Andesite

Andesitic Agglomerate

Shimajiri Group

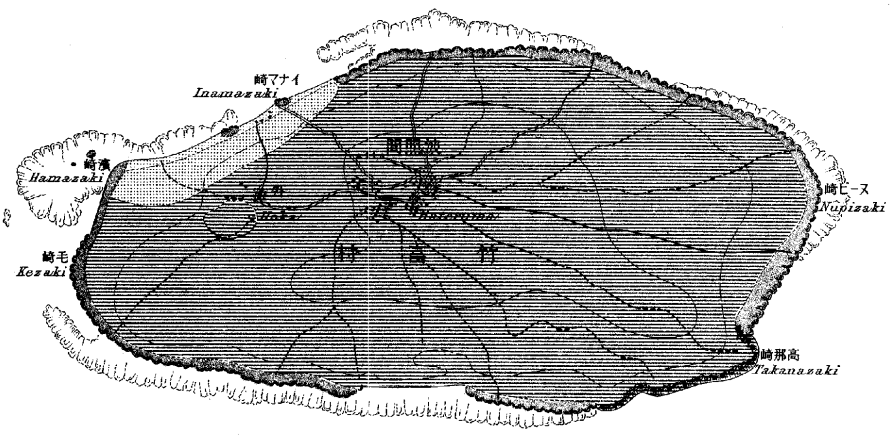
Yaeyama Coal Bearing Group

Strike and Dip

Fault

Fassil Locality

GEOLOGICAL MAP OF HATERUMA-JIMA

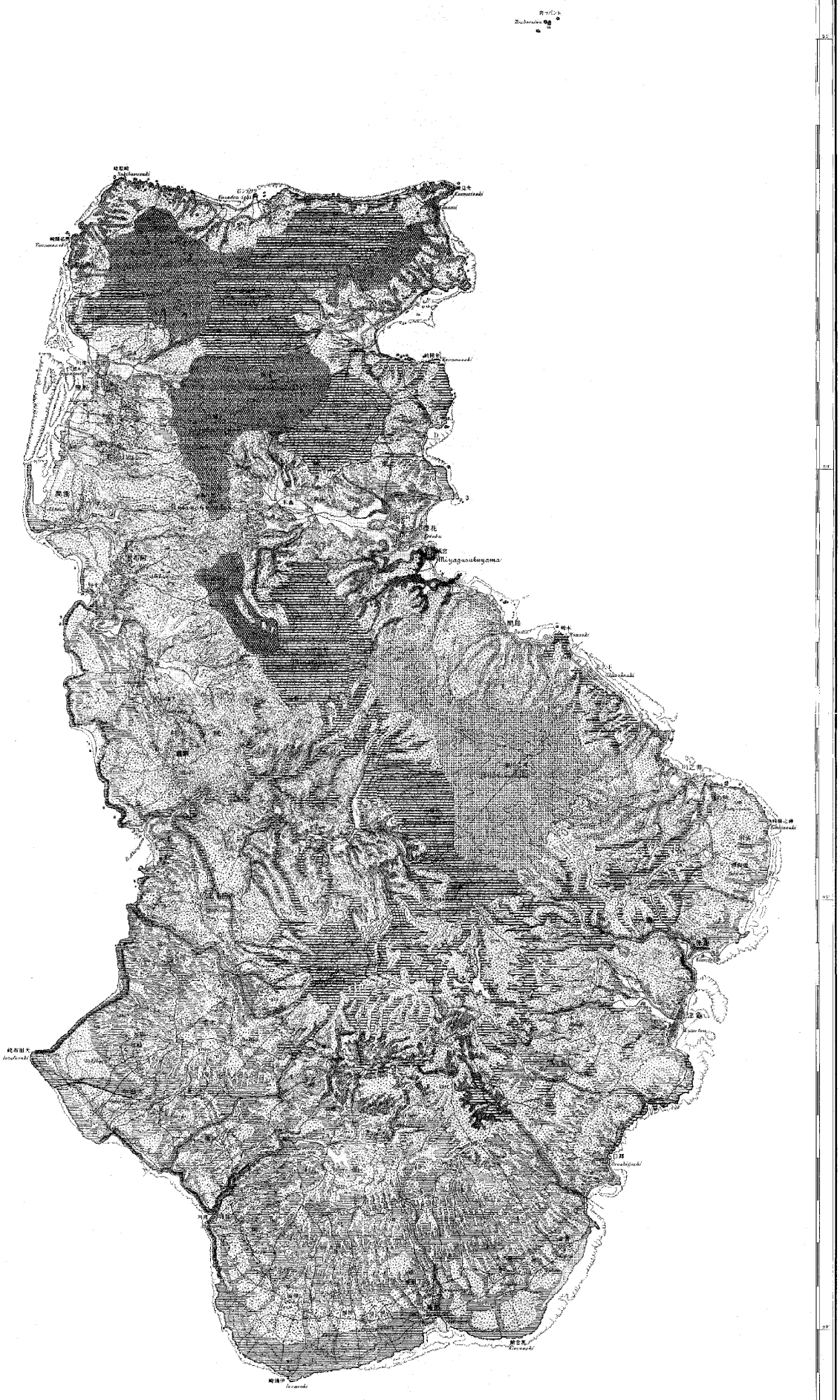


123°44′30″ 4′5″ 4′9″
7′ 7′
5′ 5′
24°1′ 24°1′
123°44′30″ 4′5″ 4′9″

崎東
Agarizaki

3′ 30′30″ 30′ 25′ 24° 24°30′ 3′

GEOLOGICAL MAP OF TOKU-NO-SHIMA



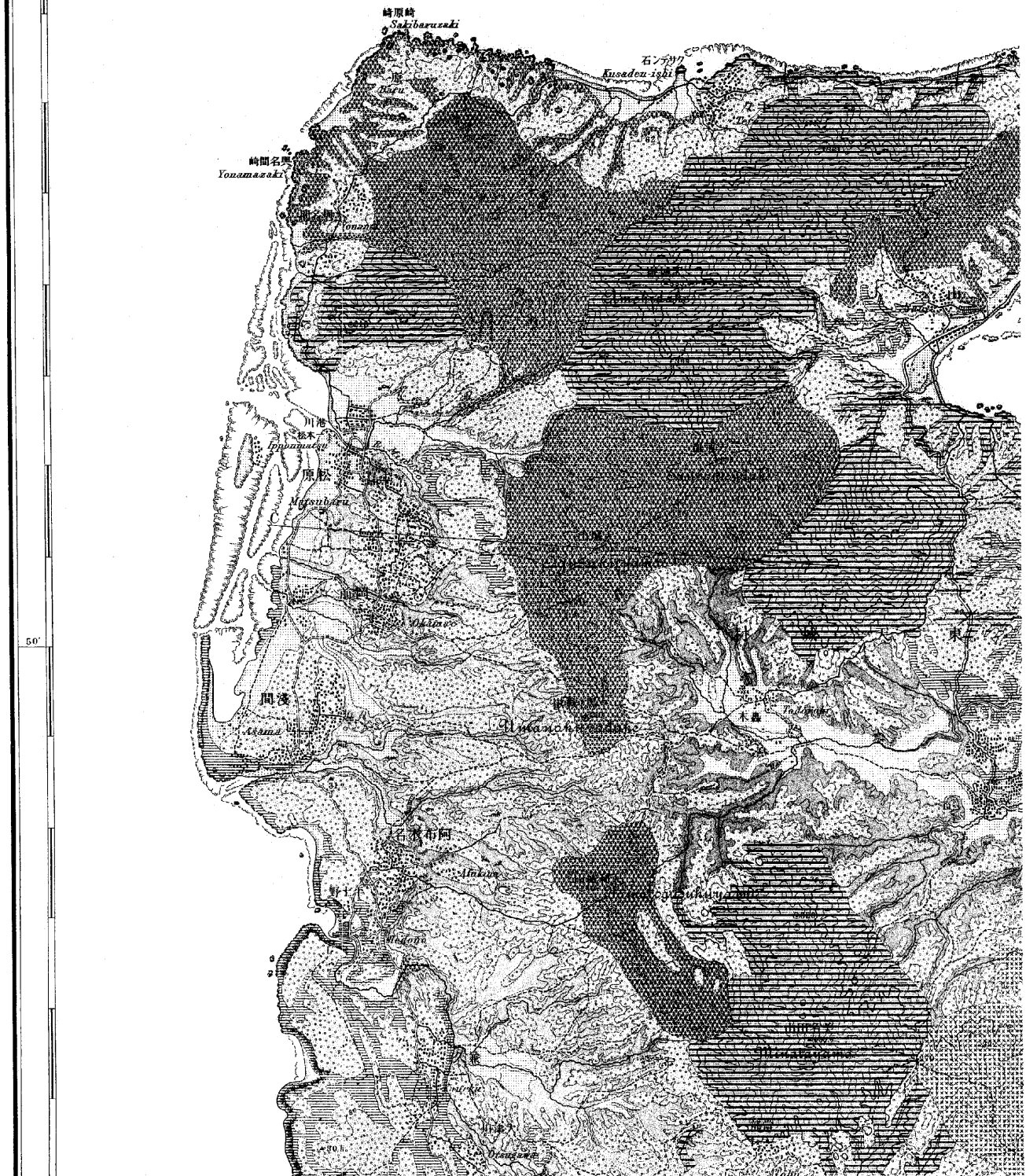
Drawn by Fusao Yamada in 1933.
Engraved by Kokuhi Ozaki in 1935.

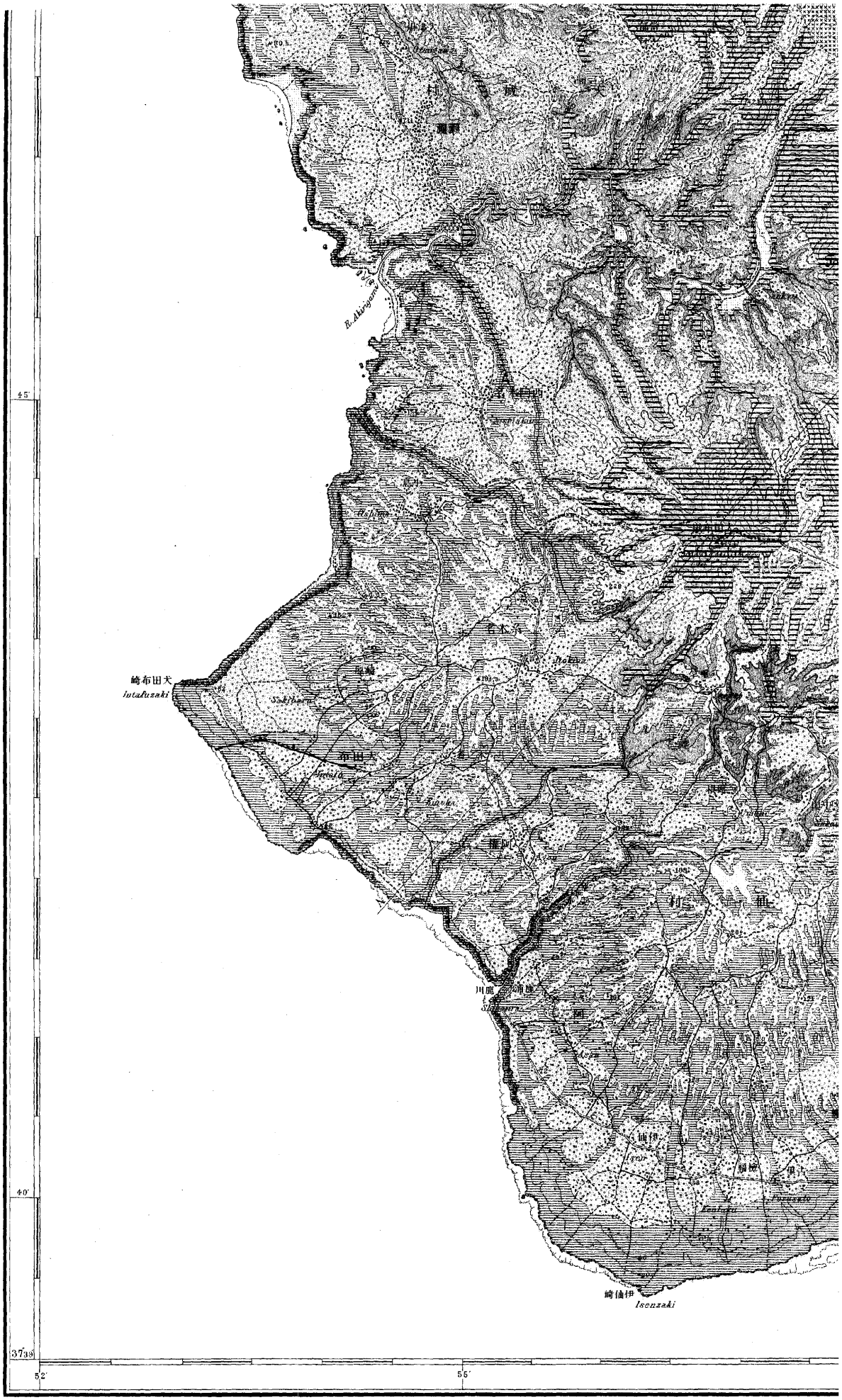
Scale 1:50,000

Contours 40 meters Vertical Interval

Science Reports of the Tôhoku Imperial University, Ser. II (Geology),
Vol. XVII, 1934, Geological Maps of the Riukiu Islands by SHÔSHIRÔ HANZAWA

GEOLOGICAL MAP OF TOKU-NO-SHI





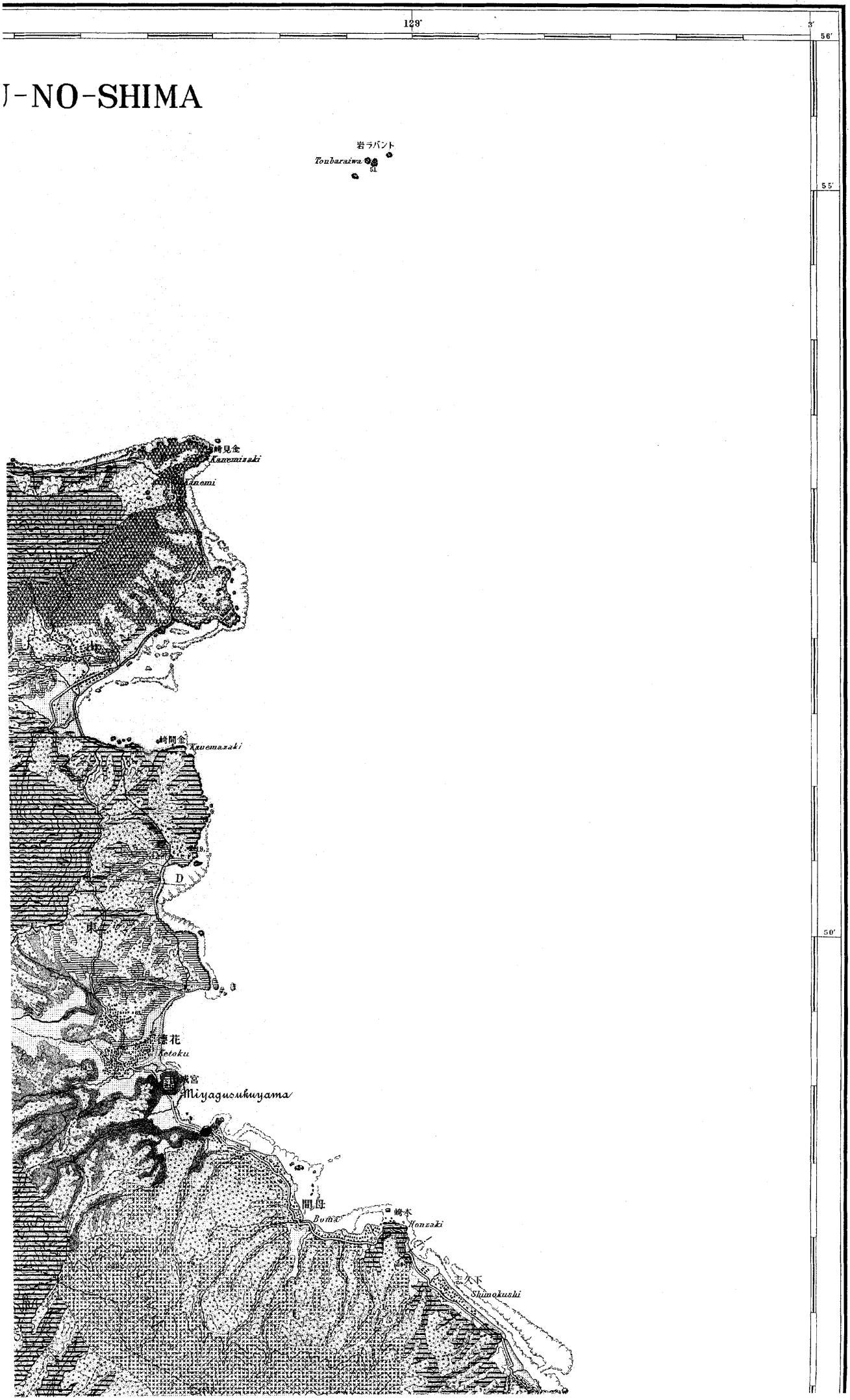
Drawn by Fusao Yamada in 1933.
Engraved by Kokudô Ôtsuki in 1933.

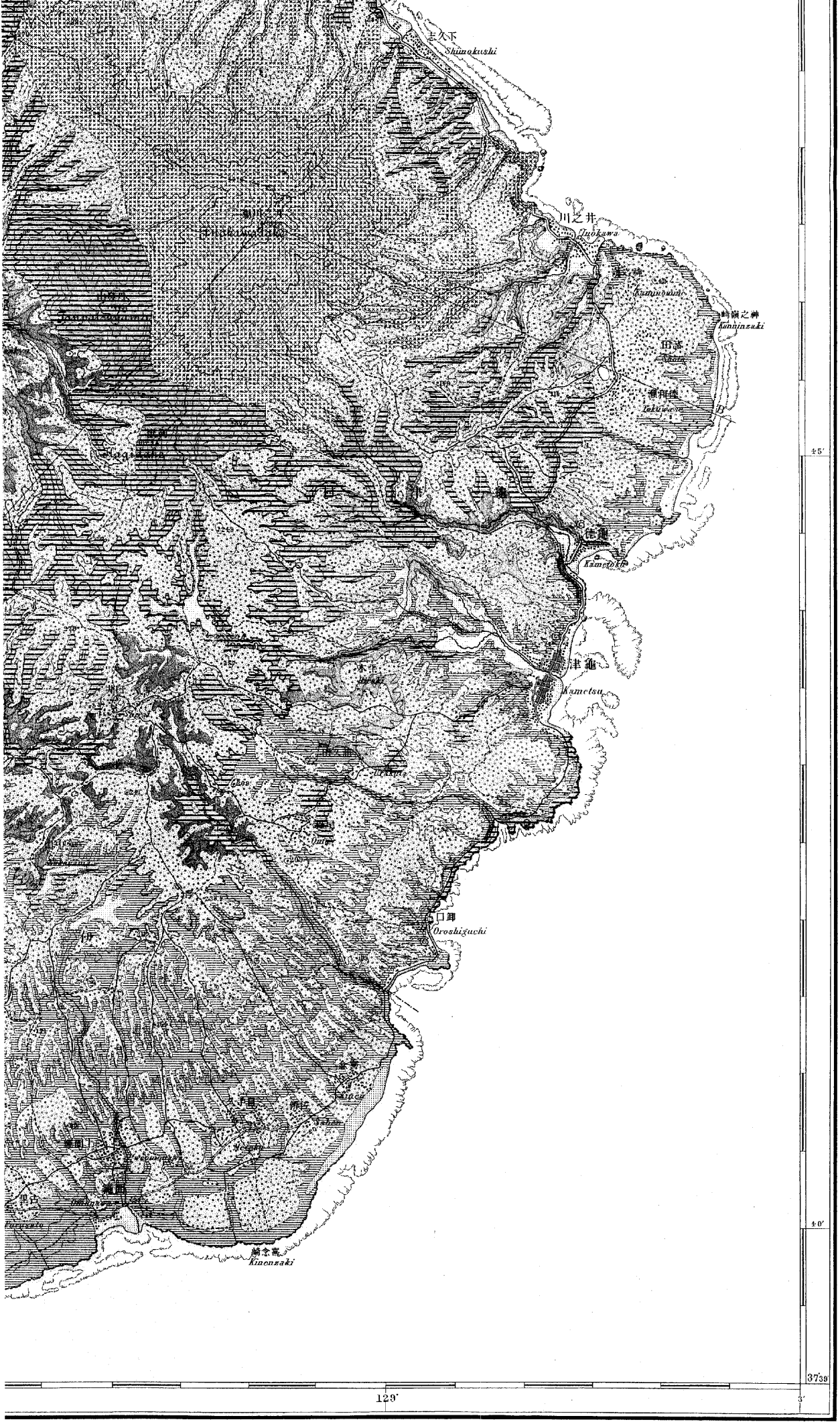
Scale 1: 50,

1000m 500 0 1000

Contours 40 meters Vert

J-NO-SHIMA


128°
3'
56'
55'
50'
岩ラバント
Toubarawa
51
金見崎
Kanemizaki
Kanemi
金岡崎
Kanemazaki
D
徳花
Tetoku
宮城
Miyagusukuyama
間切
Bunki
本崎
Honzaki
下久志
Shimokushi
Recent Sand and Gravel
Sand Dune
Kunigami Gravel
Riukiu Limestone (Upper, Limestone)
Riukiu Limestone (Lower, Sand and Gravel)
Palaeozoic Formation
Porphyrite
Diabase
Adamellite
Strike and Dip
Fault
Fassil Locality



ale 1:50,000

2000 3000 4000m

neters Vertical Interval

Science Reports of the Tôhoku Imperial University, Ser. II (Geology),
Vol. XVII, 1934, Geological Maps of the Riukiu Islands by Shôshirô Hanzawa

GEOLOGICAL MAP OF THE OKINAWA SUBGROUP

GEOLOGICAL MAP OF THE MIYAKO GROUP

(EXCL. MINNA AND TARAMA)

SURV. BY R. AOKI

GEOLOGICAL MAP OF THE NORTHEASTERN HALF OF AMAMI-Ô-SHIMA

GEOLOGICAL MAP OF THE YAEYAMA GROUP

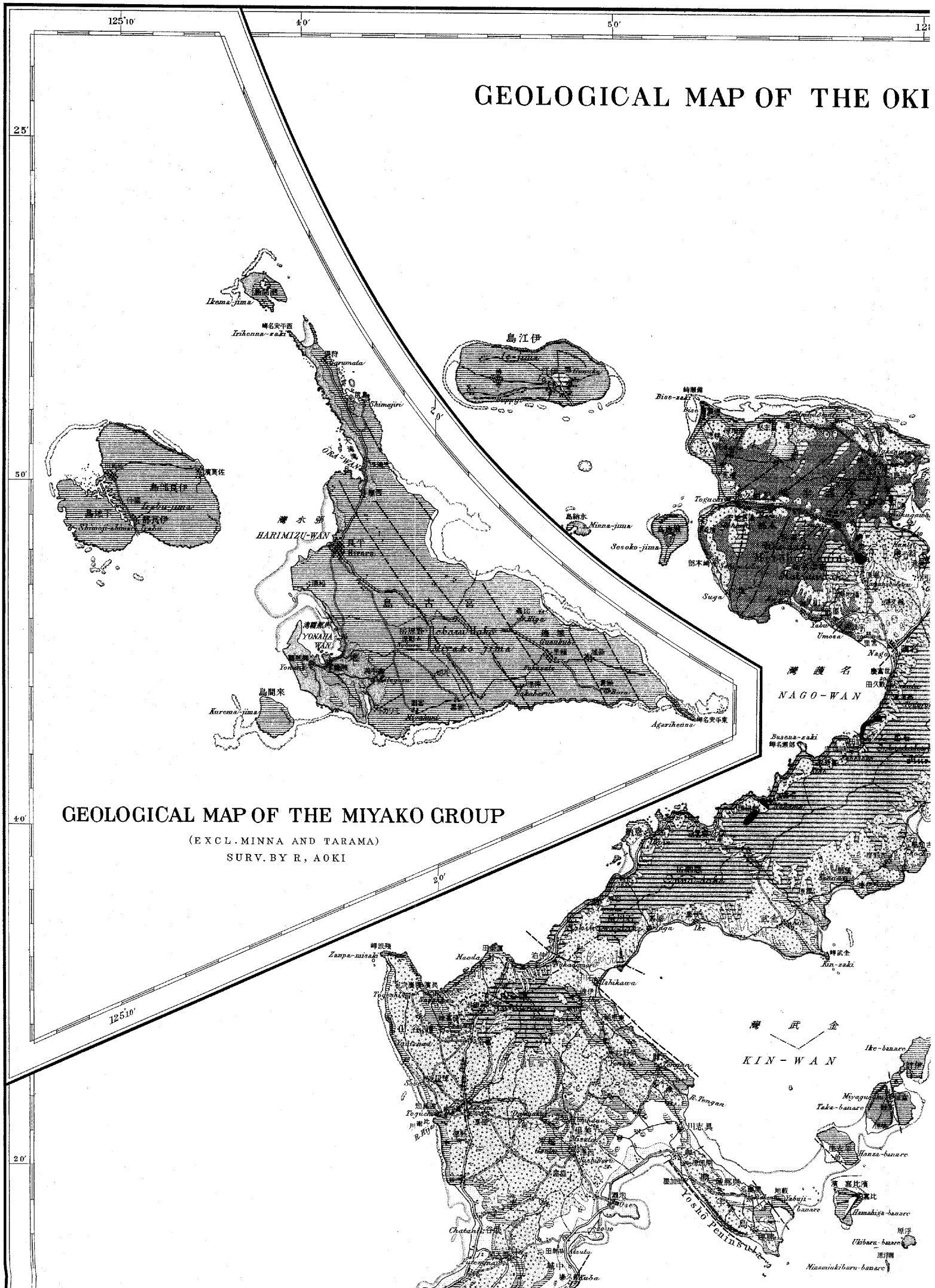
(EXCL. HATERUMA AND YONAGUNI)

Recent Sand & Gravel.
Raised Coral Reef.
Sand Dune.
Ryukyu Limestone.
Sunzi Conglomerate.
Shimajiri Group.
Sandstone and Shale (C Coal)
Andesite, Tuff and Agglomerate
Yaeyama Coal Bearing Group.
Sandstone and Conglomerate
Pellatispira Limestone
Miyara Group.
Limestone
Slate, Sandstone, etc.
Palaeozoic Formation.
Porphyrite.
Granite.
Strike and Dip.
Fault.

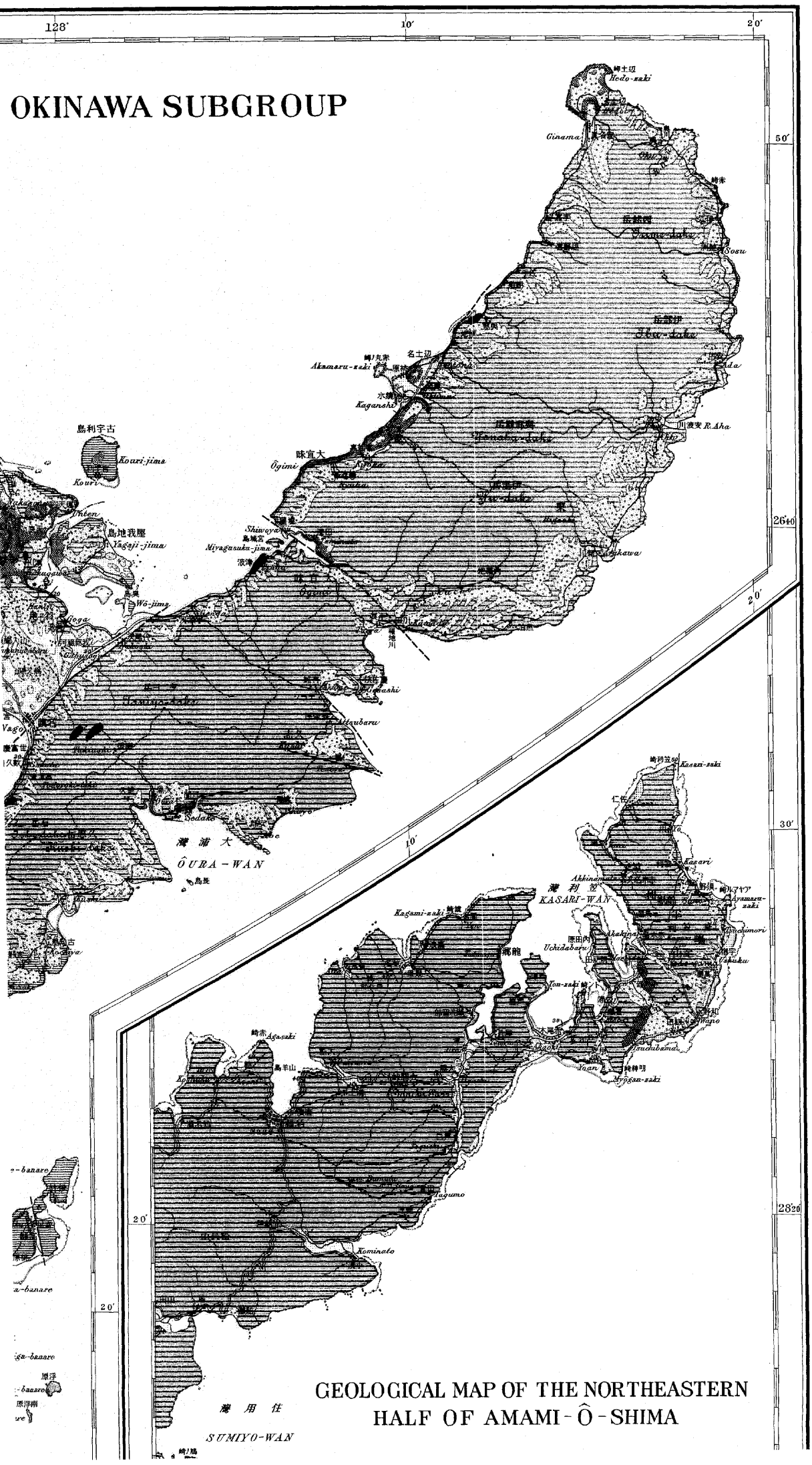
Drawn by Fusao Yamada in 1932.
Engraved by Kokichi Ôtsuki in 1933.

Scale 1:200,000

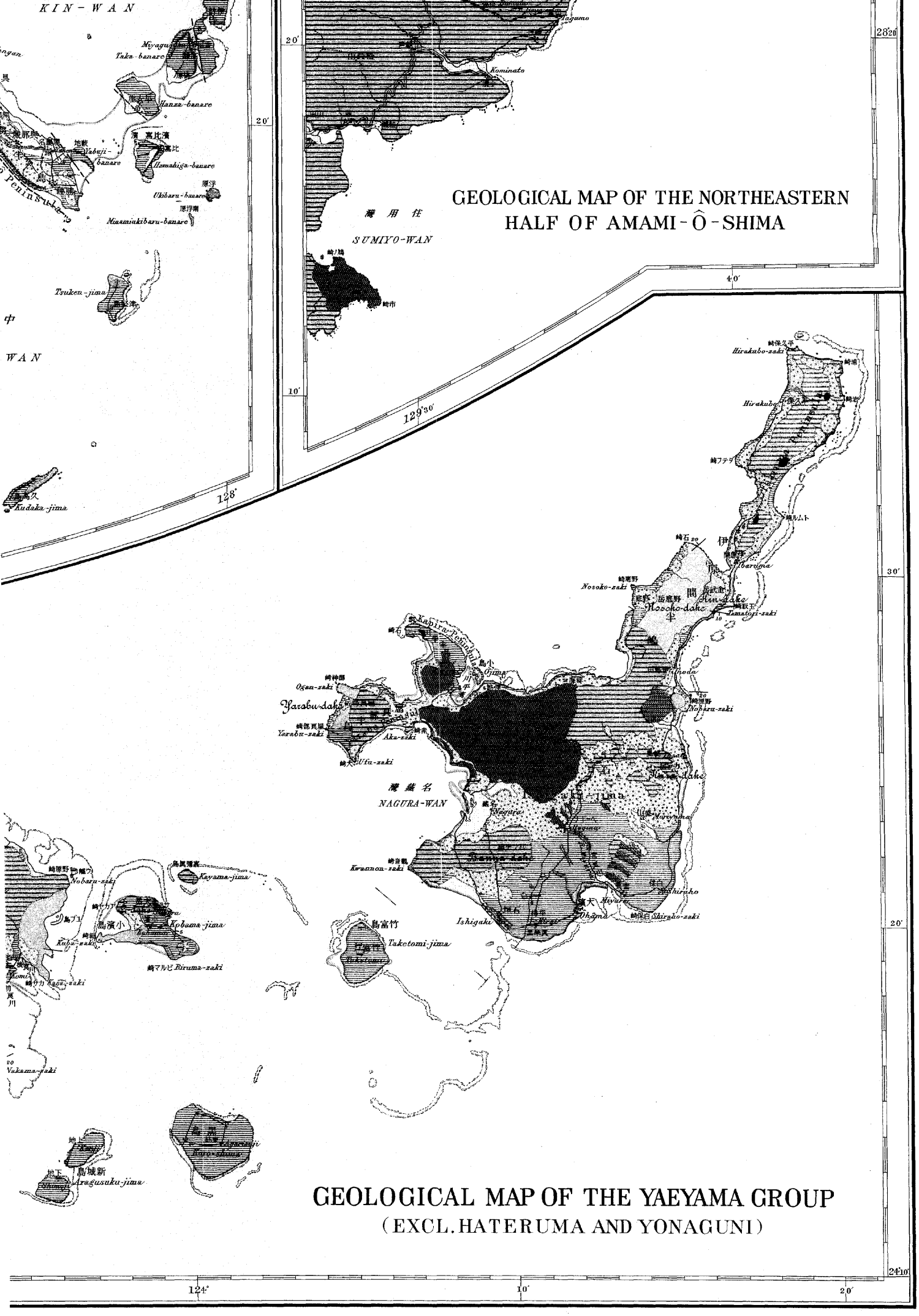
Science Reports of the Tôhoku Imperial University, Ser. II (Geology),
Vol. XVII, 1934, Geological Maps of the Riukiu Islands by SHÔSHIRÔ HANZAWA



Drawn by Fusao Yamada in 1933.
Engraved by Kokudô Ôtsuki in 1933.



GEOLOGICAL MAP OF THE NORTHEASTERN HALF OF AMAMI-Ô-SHIMA


GEOLOGICAL MAP OF THE NORTHEASTERN HALF OF AMAMI-Ô-SHIMA
GEOLOGICAL MAP OF THE YAEYAMA GROUP
(EXCL. HATERUMA AND YONAGUNI)
KIN-WAN
SUMIYO-WAN
NAGURA-WAN
Scale 1:200.000
5 10 15 Km
128°
129°30′
124°
10′
20′
30′
40′