50. *Petrographical Notes on the Dacitic Pumice from Kita Daitô-zima (Kita Ooagari-zima), one of the Southwestern Islands of Japan.*

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Introduction.

About 320 km. east of Okinawa-zima, one of the Ryûkyû island chain in the Pacific, is a linearly-arranged group of three islands, Okino Daitô-zima (Rasa I.), Minami Daitô-zima, and Kita Daitô-zima, aligned in the order given in a S. to N. direction, and separated from the Ryûkyû island chain by a trench (Ryûkyû trench), the depth of which varies from 6000 m. to 7000 m. Each island rises as a separate mountain from the ocean floor, from depths of 1000 m or more, and consisting of double or triple rock-rings encircling a central basin, presents remarkable topographical analogies with existing atolls in the Pacific. Okino Daitô-zima in 131° 11′ E. and 24° 28′ N., is about 1 km. across and 33 m. above sea level. So far as can be made out from parts

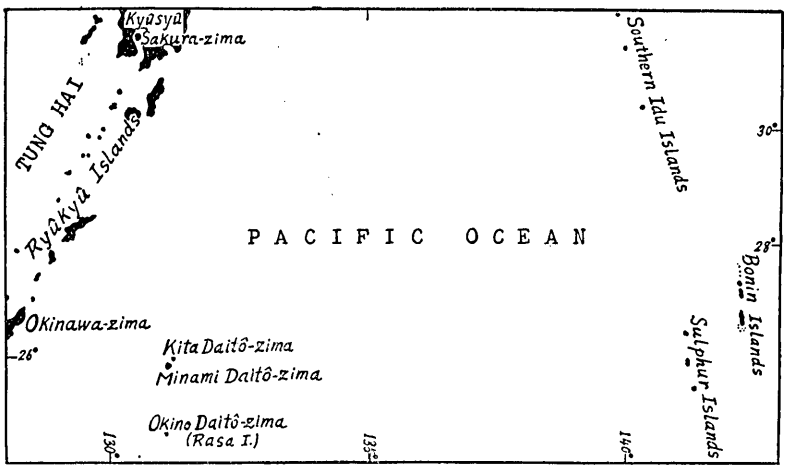

Fig. 1. Index map showing the position of Kita Daitô-zima.

exposed to view, the islet is built up entirely of coral reefs, besides phosphatic deposits formed by the chemical action of guano on the underlying coralline limestone. Minami Daitô-zima, situated 131° 13′ E. and 25° 50′ N., is about 6 km. in diameter and 52 m. above sea level. Kita Daitô-zima, which lies about 8 km. N. N. E. of the northern side of Minami Daitô-zima, is about 5 km. in longest diameter and 71 m. above sea level. According to Prof. R. Aoki[1], who, in company with Prof. H. Yabe, made a geological investigation of these two islets, Minami Daitô-zima and Kita Daitô-zima, it was found that they are built up practically of a limestone formation ("Daitô limestone"), covered with a subsoil of terra rossa type. The limestone, which in places may be called coral limestone and Halimeda limestone, contains reef-forming corals, foraminifera, calcareous algae, polyzoa, and mollusca. On the northern island, however, some phosphatic deposits and pumice beds are sandwitched in between the limestone and the subsoil. The phosphatic deposits, which are worked in the island, contain 16·38—52·16 % P_2O_5, besides Fe_2O_3, Al_2O_3, and H_2O. The pumice beds, about 3 m. thick, form a terrace resting on the phosphatic deposits.

The pumice beds of Kita Daitô-zima, which show an almost horizontal stratification, and suggest an old submarine deposit, consist virtually of pumice. This pumice is worth noting in that neither an insular nor a submarine volcano whence they might have been derived, is to be found anywhere in the vicinity of the limestone island.

The following notes refer to ten specimens of the pumice, all of which were collected by Mr. T. Sugiyama from the pumice beds at the Tamaki-taira mine on the island. Among the specimens, which are alphabetically marked from *A* to *J*, nine (*A*, *B*, *C*, *D*, *E*, *F*, *H*, *I* and *J*) are augite-bearing hypersthene-dacite, and the remaining (*G*) augite-bearing hornblende-hypersthene-dacite.

Petrography.

(1) *Augite-bearing hornblende-hypersthene-dacite.* (Fig. 2.)

Megascopic Characters.—The pumice of augite-bearing hornblende-hypersthene-dacite, which is round and about 3 cm. in diameter, is white to ash-gray, with a porous and friable texture. Phenocrysts, up to 1 mm. in diameter, of plagioclase and quartz are scattered through the vitreous base. There are also grouped phenocrysts of plagioclase.

1) R. Aoki, *Jour. Geol. Soc., Tokyo*, **41** (1934), 341~343.

The phenocrysts of the mafic minerals, pyroxene and hornblende, are scarcely visible to the naked eye.

Microscopic Characters.—Microscopically, the pumice, perpatic in fabric, consists of phenocrysts of plagioclase, quartz, hypersthene, hornblende, augite, and magnetite, the remainder being a holohyaline base densely charged with vesicles.

The plagioclase, which is euhedral and 0·5~1·0 mm. in diameter, is usually twinned according to the albite and Carlsbad laws. Zoning of less and more calcic plagioclases is faintly exhibited. Optically positive, $2V=76\sim80°$. The refractive indices—n_{1D} and n_{2D} in (010) or (001) —, measured with the dispersion method are 1·5525 and 1·5586 respectively, according to which the mineral is identified as andesine $Ab_{53}An_{47}$. Inclusions of colorless or pale brownish glass base are sparingly found in the mineral.

The quartz, about 0·5~1·0 mm. in diameter, with rounded outlines, usually shows irregular cracks and undulating extinction. The mineral contains minute globular inclusions of a colorless or pale brownish glass base and of dust material.

The hypersthene, which is euhedral and 0·3~1·5 mm. in length, has the following optical properties: optically negative, $2V=63·5°$; optic axial plane parallel to (010); pleochroism, X pale brown, Y pale yellowish brown, Z pale green; $n_{1D}=1·7004$. One large crystal shows very minute twinning lamellae (Fig. 3.) in section nearly parallel to (100). The mineral encloses small prisms of apatite, plagioclase prismoids, magnetite grains, and drops of the glass base.

The hornblende, which is euhedral and about 0·5 mm. in average diameter, is fresh, without suffering any resorption. Its optical properties are: optically negative, $2V=80°$; optic axial plane parallel to (010); relatively weak pleochroism, X pale brown, Y greenish brown, Z dark greenish brown; $X<Y<Z$; $n_{1D}=1·6595$, $n_{2D}=1·6742$.

The augite, which is very sparingly found, is euhedral to subhedral, about 0·3 mm. in diameter, and pale brown.

The magnetite, which is euhedral to subhedral and 0·1~0·2 mm. in diameter, occurs as isolated grains or in association with the pyroxene phenocrysts.

The groundmass, in which neither microlite nor crystallite is visible, is a water-clear glass densely crowded with round or elongated vesicles. The refractive index of the glass is 1·5020 for Na light.

(2) *Augite-bearing hypersthene-dacite.* (Fig. 4.)

Megascopic Characters.—The nine specimens of the augite-bearing hypersthene-dacite are round to subangular and 3～5 cm. in diameter. Megascopically, they are similar to the pumice above-described.

Microscopic Characters. Microscopically, the pumices contain phenocrysts of plagioclase, quartz, hypersthene, augite, and magnetite, scattered through a holohyaline groundmass.

The plagioclase phenocrysts, which are euhedral and 0·1～1·0 mm. in diameter, are twinned according to the albite and Carlsbad laws. Zoning of less and more calcic plagioclases is faintly exhibited. The refractive indices and the compositions identified therefrom are shown in Table I.

Table I.

Pumice No.	n_{1D}	n_{2D}	Ab%	Pumice No.	n_{1D}	n_{2D}	Ab%
A	1·5498	1·5561	56	F	1·5524 1·5517	1·5567 n. d.	53 56
B	1·5537	1·5588	51	H	1·5502	1·5544	55
C	1·5535	1·5588	51	I	1·5563	1·5602	50
D				J	1·5519	1·5561	53
E	1·5533 1·5481	1·5564 1·5530	51 59		1·5491	1·5533	58

Optically positive; $2V=84°$ in sample B, 81°, 82°, and 90° in F, 88° in H. Accordingly, the plagioclase phenocrysts are identified as andesine $Ab_{50}An_{50}$～$Ab_{60}An_{40}$. Excepting a few colorless glass drops, no inclusions are found in the mineral.

The quartz, which shows irregular cracks and undulating extinction, has usually rounded outlines, but sometimes a bipyramidal form indented by inlets of the groundmass. The mineral carries inclusions of the colorless glass base.

The hypersthene, which is euhedral, prismatic, and 0·2–0·5 mm in length, is sparingly found in the pumices. The mineral found in samples H and I has the following optical properties: optically negative; $2V=44°$ in H, 66° in I; optic axial plane parallel to (010); pleochroism, X pale brown, Y pale yellowish brown, Z pale green; $n_{1D}>1·7030$ in H, $n_{1D}=1·6991$ in I. The mineral is practically free from inclusions, but rarely small grains of magnetite.

The augite, which is euhedral and 0·3 mm. in diameter, is of very rare occurrence. The mineral found in pumice I shows the following

optical properties: optically positive; $2V=48°$; $c \wedge Z'=42°$; $n_{1D}=1.6920$; pale brown without pleochroism.

Magnetite, 0·1~0·2 mm. in diameter, occurs as isometric grains.

The groundmass is entirely glassy, showing a cellular structure with many vesicles. The refractive indices of the groundmass glasses of pumices A, C, and H are respectively 1·5013, 1·5010, and 1·5007.

Chemical Composition.—Chemical analysis of pumice H, which is the freshest among the nine specimens of the augite-bearing hypersthene-dacite, was made by Mr. S. Tanaka of this Institute. (Table II, 1)

Table II.

	1	2	3
SiO_2	72·40	70·16	72·75
Al_2O_3	12·16	13·85	14·54
Fe_2O_3	0·20	0·83	0·64
FeO	1·68	1·74	1·43
MgO	0·26	0·57	0·67
CaO	1·78	2·77	2·66
Na_2O	3·42	4·02	4·23
K_2O	2·48	2·90	2·43
$H_2O(+)$	3·70	3·03	0·24
$H_2O(-)$	0·80		
TiO_2	0·25	0·14	0·17
P_2O_5	0·44	0·11	0·14
MnO	0·10	0·03	0·04
Total	99·67	100·15	99·94

Table III.

	1	2	3
Q	38·86	28·53	31·65
Or	14·47	17·25	14·47
Ab	28·84	34·08	35·64
An	6·40	11·13	12·24
C	1·53	—	0·51
Di	—	1·39	—
Hy	3·24	2·95	3·68
Mt	0·23	1·15	0.93
Il	0·46	0·30	0·30
Ap	0·93	0·31	0·31

1. Pumice (augite-bearing hypersthene-dacite). Kita Daitô-zima, Analyst S. Tanaka.
2. Pumice. Moé-zima, about 1300 m. north-east from Sakura-zima in Kagosima Bay, Analyst K. Yamaguchi.
3. Hypersthene-plagioliparite, a variety of the so-called "Hai-isi" (ash-stone). Sakuhana-taira, Analyst K. Yamaguchi.

According to the C. I. P. W. quantitative system, the pumice belongs to *alsbachose* (1.3."2."4). The normative plagioclase has the composition of oligoclase $Ab_{81}An_{19}$. For comparison with this pumice, chemical composition[2] of a pumice from Moé-zima and that of a variety of the so-called "Hai-isi" (ash-stone) found in southern Kyûsyû, are shown respectively in columns 2 and 3 of Table II. Their analyses are fairly similar to that of the pumice from Kita Daitô-zima.

2) K. YAMAGUCHI, *Jour. Geol. Soc., Tokyo*, **35** (1928), 256.

Source of the Pumice.

The pumice of Kita Daitô-zima suggests, although remotely, the former existence of an insular or a submarine acidic volcano that yielded it. On the limestone island itself however there is no trace of a volcanic centre to which the pumice can be traced. According to Prof. Yabe, a boring was made under his supervision in the central basin of the island to a depth of 200 m., which unfortunately however did not reach the foundation of the island. The cores brought up were all limestone. There is therefore at present no way of telling whether the foundation is volcanic or sedimentary. Even should the foundation of the island be volcanic, it is unlikely that the pumice came from this foundation, so deeply buried beneath the limestone formation. It must have come from a volcano on a neighbouring shore, or else from a Submarine volcano in the adjoining ocean floor.

As possible sources of the pumice, we may mention two insular volcanic zones, the Huzi and the Ryûkyû Volcanic Zones, between which Kita Daitô-zima lies. The Huzi volcanic zone, in which numerous insular volcanoes, such as Ô-sima, Miyakê-zima, Hatizyô-zima, Sulphur islands, etc., are aligned in a N. N. W. to S. S. E. direction in the Pacific, far eastward of Kita Daitô-zima, consists practically of pyroxene-andesites and basalts. Although submarine eruptions have often taken place in this zone, the pumice found floating on the sea when these eruptions occurred were all of a basaltic nature. The nearest volcano to Kita Daitô-zima lies in the Ryûkyû island chain, which latter, according to Prof. B. Koto, may be divided into three concentric zones, viz., the outer Tertiary and post-Tertiary, the middle Palaeozoic, and the inner volcanic. This Ryûkyû volcanic zone comprises a number of insular volcanoes, Tori-sima, Suwanosé-zima, Nakano-sima, Kutiérabu-zima, etc., besides Sakura-zima, Kirisima-yama, Aso-san, etc. in southern Kyûsyû, which are aligned in the order given from S. W. to N. E. on the boundary between the Pacific and the Tung Hai, and which consist of pyroxene-andesites. None of these late-Diluvial and Recent andesitic volcanoes of both the Huzi and Ryûkyû zones is believed to be the source of the dacitic pumice under consideration.

Although the dacites and allied acidic effusives, that are so widely distributed in Japan, are for the most part late Tertiary or of still later age, analogous rocks of Quaternary age are also present, though of rare

3) B. Koto, *Jour. Coll. Sci., Tokyo Imp. Univ.*, Art. 3, **38** (1916), 1~237.

occurrence. In this connection, it may here be remarked that there is a linearly-arranged group (Nii-zima group) of three Quaternary liparitic islands, Kôdu-sima, Sikinê-zima, and Nii-zima, which are aligned in the order given from S. W. to N. E. in Sagami Bay. The liparites of these islands however differ in many respects, microscopically as well as chemically, from the pumice of Kita Daitô-zima. On the other hand, as shown in Table II, the latter presents some chemical analogies with the pumice from Moê-zima (An'ei-zima), an island about 1300 m. northeast of the volcano Sakura-zima in Kagosima Bay, though that is as far as the comparison holds, unless we are certain that they are genetically related to each other. According to Mr. Yamaguchi[4], Moê-zima is built up practically of a pumice bed, more than 40 m. in thickness, together with an intercalating diatom-bearing tuff. The pumice bed, which is intruded in places by pumiceous lavas corresponding to the An'ei lavas of Sakura-zima, is covered with a molluscan shell bed, about 2 m. thick. The pumice that constitutes the greater part of the pumice bed have a dacitic or liparitic composition (Table II, 2). From these facts it is inferred that the pumice bed of Moê-zima is not the product of the andesitic Sakura-zima volcano, but an older submarine deposit corresponding to the pumice-lapilli formation of the environs of Kagosima, just referred to. Moê-zima, which, according to certain old trustworthy records, is a new island that sprang up during the An'ei (1780) eruptions of Sakura-zima, is nothing but an old land block that formerly lay at the bottom of Kagosima Bay, and which was thrust up during the Sakura-zima eruptions as the result of the upward intrusion of the underlying Sakura-zima magma.

The land surrounding Kagosima Bay is a plateau of pumice-lapilli beds, more than 100 m. thick, and attaining an altitude of 230 m., and which bounds the shore of the bay in sharp perpendicular cliffs. The pumice-lapilli bed (" Plateau Formation ") is intimately associated with the so-called " Hai-isi " (ash-stone), so named on account of its having the appearance of hardened volcanic ash. The ash-stone is a group of submarine lavas that gave birth to the pumice-lapilli bed.[5] One of

4) K. YAMAGUCHI, *loc. cit.*

5) Owing to the very complicated mode of occurrence of the ash-stone, the volcanism to which the eruption of the rock is due, is interpreted in different ways by different authors, namely, fissure eruption, central eruption, and injection into the pumice-lapilli formation. B. KOTO, *loc. cit.*; K. YAMAGUCHI, *Jour. Geol. Soc., Tokyo*, 40 (1933), 377~379; T. MATSUMOTO, *Geogr. Rev., Geogr. Soc., Japan*, 9 (1933), 62~74.

these lavas, identified as trachyandesite or plagioliparite, is the nearest chemical analogue to the pumice of Moé-zima (Table II, 3). According to T. Matsumoto, similar rocks occur on Kutiérabu-zima, though much younger basic andesites are the prevalent rock type in the island. Although we do not know exactly to what extent these acid volcanics distribute in the Ryûkyû district, it is inferred that they represent the Diluvial pre-andesitic volcanism in the Ryûkyû volcanic zone. Further study of the Ryûkyû insular volcanoes may give evidence of the wide distribution of the products of that volcanism. Accordingly, if the dacitic pumice of Kita Daitô-zima is genetically related with the ash-stone and pumice-lapilli in southern Kyûsyû, then the source of the former may be located somewhere in the Ryûkyû volcanic zone, where the latter may still be found.

Conclusion.

From what has been stated, the identification of the pumice bed of Kita Daitô-zima as the pumice-lapilli formation in southern Kyûsyû, although it is no more than as inference, may be provisionally accepted. The pumice-lapilli formation, together with the ash-stone, are regarded as products of early or middle Diluvial volcanism that took place in southern Kyûsyû. Then the pumice of Kita Daitô-zima may well belong to the same period of volcanism. It is however improbable that the pumice, which floats on water, had been transported against the ocean current from southern Kyûsyû to Kita Daitô-zima, a distance of about 500 km. It is much more likely to have been fed by a vent nearer at hand in the middle part of the Ryûkyû volcanic zone, where the same volcanism would have taken place. Some of the pumice ejected during the volcanism were transported eastward to where Kita Daitô-zima now is, and they accumulated on the partly phosphatized limestone elevation, which at the time was entirely in the sea or just above sea level. Kita Daitô-zima was elevated to its present position subsequent to the deposition of the pumice.

The limestone and phosphatic deposits of Kita Daitô-zima, which are older than the pumice bed, may be dated as being approximately earlier Diluvium. Accordingly the limestone, so far as can be judged from its exposed parts, may be contemporaneous with, or somewhat younger than the Ryûkyû limestone, which is considered to be lowest

6) T. Matsumoto, *Bull. Vol. Soc., Japan*, 2 (1934), 17~18.

Sikisima (the Japanese Pleistocene) or uppermost Miduho (the Japanese younger Tertiary).

In conclusion the writer desires to express his sincere thanks to Prof. Yabe for the loan of the pumice specimens described in this paper from the collection of the Tôhoku Imperial University.

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50. 北大東島産浮石の岩石學的研究

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沖繩縣島尻郡に屬する南・北兩大東島は沖ノ大東島（ラサ島）と共に隆起環礁に類する地貌を有し，大部分所謂大東石灰岩より成り，テラ・ロザ式の表土にて蔽はれてゐる．北大東島には此他に燐鑛層及び浮石砂層が石灰岩と表土との間に介在してゐる．浮石砂層は約 3 m. の厚さを有し，殆ど水平の層理を示して燐鑛層を蔽ふ．

北大東島の玉置平採鑛場附近の浮石砂層中より採集せられた浮石標本 10 個の岩石學的性質を研究せる結果に依れば，其中 9 個は含普通輝石・紫蘇輝石・石英安山岩に，殘りの 1 個は含普通輝石・閃石・紫蘇輝石・石英安山岩に屬する．而して，前種の 1 個は化學分析の結果，酸性火山岩の成分を有し，アメリカ式分類法に依れば *alsbachose* (1.3''.2.''4.) に屬する事が判明した．

北大東島中央盆地にて行はれた利根式コア・ボアリングの結果に依れば，同島は地表下 200 m. 迄は凡て石灰岩である．從つて，同島の基盤の性質は未だ判明しないが，假りに其基盤が火山質であつたとしても，上記浮石が此基盤より供給せられたとは考へられない．故に該浮石の本源は近隣の火山島或は海底火山に求められなければならない．北大東島に最も近い火山は琉球火山帶中の火山であるが，此火山帶は中性乃至基性の輝石安山岩類より成る．又，北大東島の遙か東方には富士火山帶の南方延長なる伊豆諸島及び硫黄列島等の火山島が在るが，之等の大部分は主として基性の輝石安山岩類或は玄武岩類より成る．同方向の海底火山より屢々噴出せる浮石も亦主として基性の安山岩に屬する．從つて北大東島の浮石が之等洪積期末乃至現在の火山の一より供給されたとは考へられない．伊豆七島中 神津島・式根島・新島は流紋岩類に依つて構成されてゐるが，此流紋岩類は北大東島の浮石と岩石學的性質を異にしてゐる．

然るに北大東島の浮石は九州南部鹿兒島灣周邊地域に擴大なる臺地を形成してゐる浮石灰砂層中の浮石及び此地層と密接な關係を有する所謂灰石(又は泥熔岩)の一種に化學成分が極めてよく類似してゐる．此事實のみでは單なる推定に過ぎないが，兩者は同時代の噴出物で且つ成因的に同源に屬するのではなからうか．若し此の推定が正しいとすれば，九州南部の浮石灰砂層及び灰石は略洪積初期乃至中期の火山噴出物と考へられてゐるから，北大東島の浮石も亦略同時代と推定される．但し，九州南部にて噴出した浮石が正南方の北大東島附近迄約 500 km. の海上を海流に逆つて運搬される事は不可能かもしれないから，北大東島の浮石を供給した火山はもつと手近に在つたと考へられる．松本唯一教授に依れば，口永良部島にも鹿兒島附近の泥熔岩に類似する岩石が同島の最新期火山を形成してゐる．從つて，此類の火山岩は琉球火山帶の洪積期末乃至現世の輝石安山岩類の噴出に先驅した火山活動の産物として薩南諸島より或は琉球方面に迄亘て廣く分布してゐた事

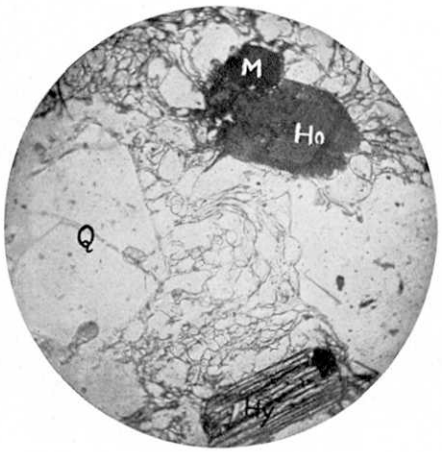

Fig. 2. Augite-bearing hornblende-hypersthene-dacite. ×27. See p. 3.
Q....quartz,
Hy....hypersthene,
Ho....hornblende,
M....magnetite.

Fig. 3. *Ditto.* Crossed Nicols. ×27.
A....augite,
Hy....hypersthene showing twin-lamellae.

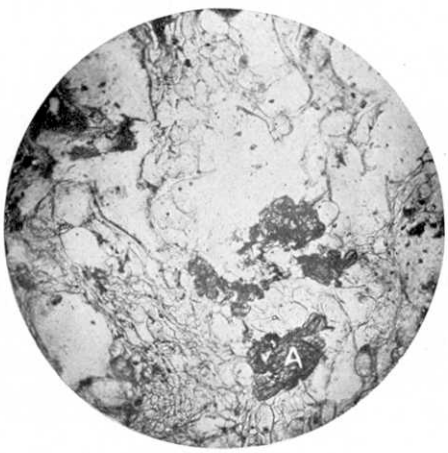

Fig. 4. Augite-bearing hypersthene-dacite. ×27. See p. 4.
A....augite.

Microphotographs of the Pumice from Kita Daitô-zima.

（震研彙報 第十二號 圖版 津屋）

もあり得る．若し然りとすれば，此方面の海底火山或は島上火山から洪積期中期頃噴出した浮石の若干が其當時の北大東島の石灰岩上に沈積し，かくして出來た浮石砂層が此石灰岩島の相對的隆起に依つて現在の如く北大東島の上に露れてゐるものと考へられる．

要するに北大東島浮石の噴出地點はまだ何處とも斷定されないが，此浮石と鹿兒島附近の浮石灰砂とが成因的に關係してゐて略同時代の噴出物とすれば，浮石層に被はれてゐる大東石灰岩の少くとも最上部及び燐鑛層は大體に於て洪積初期に生成せられた事になる．他方に於て大東石灰岩の時代が古生物學的に決定さるれば，浮石の堆積時代が明かとなり，從つて未だ決定的でない鹿兒島附近の浮石灰砂層の時代も確められる．