23. *Geological Growth of the Tôkyô Bay.*

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(Read May 19, 1931.—Received May 17, 1931.)

The Tôkyô Bay is a rectangular depression in the Kwantô tectonic basin,[1] with an extension of 50 km. from north-east to south-west and 30 km. from north-west to south-east. Its four borders are more or less irregular; while the major irregularities are due to prograded deltaic deposits of the Sumida-gawa, Rokugô-gawa and several other rivers as well as to the sand spit of Futtsu, minor ones are the consequence of a land-submergence of 150± m., thereby the depression of the Tôkyô Bay and the ancient valley anteceding the Uraga Channel being invaded by transgressing marine water. This submergence of land was followed by an emergence of at most 20 m. The outline of the Tôkyô Bay with rectilinear borders suggests its tectonic origin; it is probably controlled by faults in two systems, one of NE-SW trend and the other of NW-SE. It may also deserve our attention that all the large swamps and lagoons (Tega-numa, Imba-numa, Kasumiga-ura and Kita-ura), dependent to the drainage system of the Tone-gawa, are situated on the north-eastern extension of this depressed zone.

The higher, Tama-, and the lower, Musashino-terraces[2] into which the plateau-surface of the Kwantô tectonic basin is divided are arranged in discordance with the area occupied by the Tôkyô Bay; this fact is a remarkable testimomy to the essential youth of the Tôkyô Bay, suggesting that its foundering dated later than the building of the two terraces, or in other words, later than the tectonic movements which led to the building of the Kwantô basin by basin-shaped uplift of the marine Narita Series; or more correctly, it may be considered as an episode of a later

1) H. YABE and R. AOKI, "The Great Kwantô Earthquake of September 1, 1923, Geologically Considered," *Ann. Rep. Saitô Gratitude Foundation*, No. 1 (1926).

2) R. AOKI and R. TAYAMA, "Topography and Geology of the Kwantô Tectonic Basin with Special Reference to Its Western Border," *Saitô Gratitude Foundation, Scientific Report*, No. 8 (1930), (in Japanese).

date intervening this long continued tectonic movement which gave rise to the Tama- and Musashino terraces. Perhaps it was also anteceded by the deposition of the Kwantô loam upon the surface of the two terraces.

Hence the Tôkyô Bay is not a relic sea of the older, Palaeo-Tôkyô Bay,[3] in which the marine sediments of the Narita Series are thought to have been deposited.

The Tôkyô Bay is shallow, not exceeding 60 m. in depth; the basin was in terrestrial condition before the land submergence referred to above, as indicated by the drowned valley in the Uraga Channel.[4]

The Uraga Channel is zigzag-shaped, parallel-sided and 10 km. broad on the average; its floor gently descends from 60 m. at the north to 80 m. at the south, and has a drowned valley running lengthwise on its floor. There is no trace of the Tama- and Musashino-terraces fringing the periphery of the channel, and it has in common with the outer sea and the Tôkyô Bay only the coastal topography of the last land-submergence and raised-beaches telling younger, the last emergence.

The silt beneath the soil of the Downtown of Tôkyô is an estuarine deposit of the time of the last land-submergence, later uplifted; it occasionally contains numerous mollusca characteristic of a muddy bottom, as that once excavated at Yûraku-chô, Kôjimachi-ku[5]; it is a kind of bay-head deposits in drowned valleys, and contemporaneous deposits of similar nature occur also along the both sides of the Uraga Channel, for instance, at Uraga on the west side and Minato on the east. The molluscan fauna of these raised beaches does not essentially differ in its constitution from the recent one living in the Tôkyô Bay under the same physical condition.

The contemporaneous raised beaches exist not only along the Sagami Bay coast of Sagami and the Miura Peninsula, and around the Bôsô Peninsula outside the Uraga Channel, but also almost everywhere around

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3) In Ôiso block, Miura and Bôsô Peninsulas, the grouping of the strata shows that we are dealing with the surviving remnants of the late Neogene range that ran along the northern border of the present Sagami-nada and crossed the Uraga Channel; this horst mountain struck farther south-south-eastward into the Pacific. The crust-block sunken north of it converted into a bay, open to east and south-east; for this Pleistocene bay, the name Palaeo-Tôkyô Bay was proposed by me many years ago. H. YABE, "Bôsô Peninsula" *Gendai no Kwagaku*, 2 (1914), No. 4, (in Japanese).

4) H. YABE and R. TAYAMA, "On Some Remarkable Examples of Drowned Valleys found around the Japanese Islands," *Records Oceanogr. Wks.*, Japan, 2 (1929), No. 1.

5) G. YAMAKAWA, "Alluvial Mollusca from Yûraku-chô," *Jour. Geol. Soc.*, Tôkyô (1909), (in Japanese).

the Japanese Islands where they were not destroyed by later abrasion, either marine or subaerial; there are primarily absent only where a local crustal disturbance caused the shifting of the strand line more in opposite sense, as, for instance, in the southernmost part of the Kitakami Mountainland and in the Matsushima-Shiogama district.[6]

The raised beaches constitute one particular group of terraces which are geologically the youngest ones among the so-called "Post-Kwantô loam terraces" of Messrs. R. AOKI, and R. TAYAMA,[7] and may hereafter be called "the 15 m. beaches" for the sake of brevity, though their altitude much differs from place to place and ranges usually from less than 5 m. to 20 m. in the Kwantô region.

One of the "15 m. beaches", which is the most instructive of all, is the coral bed, or more correctly coral reef, of Noma near Tateyama and along the Tateyama-wan, in the province of Awa, where an alluvial plain has its surface some 20 m. higher than the present sea-level. As shown by many excavations at Okanoma and several other places near by, there is in a more or less extended distribution an incipient fringing reef of reef-building corals beneath the alluvial silt, which had once grown in drowned valleys, cut into Neogene rocks, at the time of the last land submergence, referred to above.

The semifossil reef is about 2–3 m. thick and consists of coral heads or stocks in upright position, the basal ones of which attach directly to the rock-floor, Neogene tuffs of the Miura Series, or to angular or subangular blocks of the same rocks torn off from the very floor and rolled.

Other common organic remains in association with these corals are thick-shelled mollusca, all found in fresh condition, not seldom with colour pattern and bivalves having both valves usually intact. The corals are likewise well preserved, even delicate spinules of septal margin usually showing no trace of damage. Worthy of special note is further the circumstance that there are almost no rolled pieces of coral stocks around the reef; at least these were not seen in an excavation of Okanoma which I had an opportunity personally to examine a score of years ago, and in another one very recently prosecuted by members of the Institute

6) H. YABE, "Excursion to Matsushima and Sendai; Geological Guide," Guide-Book, Excursion C 3, published by the Pan-Pacific Science Congress, 1926.

7) R. AOKI and R. TAYAMA, *op. cit.* R. TAYAMA, "Topography of the Bôsô Peninsula, with Special Reference to the Correlation of Abrasion Planes," *Saitô Grati'ude Foundation, Scientific Reports*, No. 9 (1930), (in Japanese).

of Geology and Palaeontology, Tôhoku Imperial University. All these facts seem to support the view that we have here an incipient fringing reef grown in a rather calm water immediately after the land submergence.

There is a divergence of opinions as to the geological age of the Noma coral reef. Dr. M. YOKOYAMA at first maintained the Pleistocene warm age instead of glacial in Japan on the evidence of this formation, but later assigned it to the youngest Pleistocene.[8] In my opinion it is early Holocene as already expressed elsewhere.[9] Mr. T. KURODA of the Institute of Geology and Mineralogy, Kyôto Imperial University, verbally communicated me that the molluscan fauna of the semifossil reef of Noma is similar to the recent one living in the adjacent warm water. The question of the geological age of the coral reef is intimately related to the larger problem how to mark the Pleistocene-Holocene boundary in the Japanese Islands, where we have no trace of past glaciation else than scanty small cirques on the high peaks of the Hida-Shinano Mountains or the so-called Japanese Alps[10] and the Hidaka Mountains of Hokkaidô. The topographical relation of these cirques to the valley-terraces in the mountains and that of the latter to the Tama and Musashino terraces have not yet been thoroughly studied by any of us, though these are topics of our keen interest.

In this connection, very interesting is a comparison between the British Islands (especially of non-glaciated areas) and the Japanese Islands as to the change of sea-level and climate during the latest Cenozoic. Our 15 m. beaches and terraces may approximately correspond to the so-called Neolithic beaches of the British Islands and the stage of land-submergence preceding to the emergence has its exact copy in the land-submergence by which the stage of the Neolithic beaches is separated from the so-called Forest stage, while the Forest stage seems to found its counterpart in the time during which our Tama and Musashino terraces

8) M. YOKOYAMA, "Climatic Changes in Japan since the Pliocene Epoch," *Jour. Coll. Sci. Imp. Univ.*, Tôkyô, **32** 1911), Art. 5 M YOKOYAMA, "Mollusca from the Coral-Bed of Awa," *ibid.*, **45** (1924), Art. 1.

9) H. YABE and R. AOKI, "A Summary of the Stratigraphical and Palaeontological Studies of the Cenozoic of Japan, 1920 to 1923," *Proc. Pan-Pacific Sci. Congr.*, Australia (1923).

10) N. YAMASAKI, "Glaciation of the Hida Mountains," *Geol. Soc.*, Tôkyô, **21** (1 14), (in Japanese). K. ÔSEKI, "Some Notes on Glacial Phenomena in the North Japanese Alps," *Scot. Geogr. Mag.*, **31** (1915).

were formed. Then the best way from the stand-point of diastrophism is, I think, to mark the dawn of the Holocene with the last land-submergence in the Japanese Islands, as already definitely stated by me several years ago.[11] So far as I am now aware, all the neolithic human sites and shell mounds in the Kwantô region with dressed and polished stone implements as well as potteries are situated on the 15 m. beaches and terraces or on the Kwantô loam covering the Tama- and Musashino-terraces.

Finally it remains to settle the relative antiquity of the depression of the Tôkyô Bay and the building of the older terraces of the "Post-Kwantô loam terraces", because the latter, like the former, is a geological event preceding the last land-submergence. An answer to this question can be obtained by a glance of the terrace map of the northern part of the Bôsô Peninsula by Mr. R. TAYAMA,[12] which distinctly shows that the older terraces of the "Post-Kwantô loam terraces" are nearly conformant in their areal distribution with the present drainage system of the district, fringing even small, apparently young side-valleys. Hence there is almost no doubt about that the older terraces of the "Post-Kwantô loam terraces", like the younger ones, are of the later origin than the depression of the Tôkyô Bay, at least in this district now we specially concern, though of course it is never the truth to say that every one of the terraces of this category has the same history, because we have good reason to believe that the emergence of land was continuously in progress in the Kwantô basin as before as after the foundering of the Tôkyô Bay, and the possibility is by no means excluded that some of the terraces are decidedly of an earlier date.

Summary.

From the foregoing remarks it appears reasonable to subdivide the Shikishima Period (the Japanese Pleistocene+Holocene)[13] by the use of various diastrophic criteria in the following way, in so far as the Kwantô region is concerned.

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11) H. YABE and R. AOKI, "A Summary of the Stratigraphical and Palaeontological Studies," *loc. cit.*

12) R. TAYAMA, "Topography of the Bôsô Peninsula," *loc. cit.*

13) H. YABE and R. AOKI, "A Summary of the Stratigraphical and Palaeontological Studies," *loc. cit.*

1. Land submergence in the early Shikishima Period and the deposition of the marine Narita Series in the Palaeo-Tôkyô Bay on the submerged land surface called by YABE the Pre-Narita and believed to be equivalent to the Pre-Tama of Messrs. AOKI and TAYAMA.[14]

2. Land emergence, elevating the Narita Series above the sea level; subaerial denudation and the building of the Tama terraces.

3. Crustal disturbance as indicated by the different behaviours of the Tama and Musashino terraces.

4. Land emergence and subaerial denudation continued; building of the Musashino terraces.

5. Deposition of the Kwantô loam upon the surface of the Tama and Musashino terraces.

6. Land emergence and subaerial denudation continued; depression of the Tôkyô Bay and building of the older ones of the "Post-Kwantô loam terraces".

7. The last land submergence; giving rise to the drowned valleys of the higher level[15]; the deposition of the sediments of the 15 m. beaches and terraces; growth of the Noma fringing reef. Early Holocene.

8. The last land-emergence; building of 15 m. beaches and the other terraces of the younger group of the "Post-Kwantô loam terraces".

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23. 東京灣の出現

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今日の東京灣の占むる地域は、其の輪廓より窺ふに、北西—東南及び北東—西南の二組の地質構造線の間に挟さまれたる沈下地塊の如し。然して此の沈下は青木及田山兩氏の多摩及び武藏野臺地の形成後にして且つ後關東ローム段丘の內、新期のものに先んず。此れ東京灣盆地の出現の時期にして此の盆地が海水の浸す所となりたることは上述最後の段丘の一種たる十五米隆起汀線海成堆積層の示す陸地沈降卽ち海浸の時期なり。

此の日本群島最近地史の上に著るしき陸地沈降及び上昇は英群島の所謂ネオリシック、ビーチの示す水準變化と全く其の軌を一にして又同時代のものなるべし。

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14) R. AOKI and R. TAYAMA, "Geology and Topography of the Kwantô Tectonic Basin," *loc. cit.*

15) H. YABE and R. TAYAMA, "On Some Remarkable Examples of Drowned Valleys," *loc. cit.*

成田層堆積當時に於ては、箱根の北より大磯地塊、三浦及び房總兩半島を連ぬる東西趨向の山地又は丘陵地ありて、其の北に成田層の沈積を見たる一大海灣あり。東及東南太平洋に開く。然して上記の事實より現在の東京灣は此の所謂古東京灣とは全く別個の成生に係り前者は後者の遺跡ならざるを知る。