4. *Limnology of Two Lakes on the Oceanic Island, Kita-Daitô-zima.**

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Kita-Daitô-zima¹⁾ encloses many marshes and small water bodies in its interior basin, surrounded by hills in double rows assuming circular walls, and three of them are deep enough to be called lakes. On March 11, 1934, T. Sugiyama and R. Endô sounded two of them by means of a canoe, while staying on the island to lower a 200 m deep boring through the limestone complex of which the island is almost entirely built. The water, bottom mud and plankton samples from these lakes were forwarded to the writer for examination. The present paper deals with the limnology of the lakes based on these materials and on general information given by T. Sugiyama and F. Yamanari.

One of these lakes, Aka-ike, has an elevation of 1.17 m above sea-level. It is surrounded by dense growth of *Pandanus tectorius* Sol., while the greater part of the central basin of the island is now given up to sugar cane plantation (Figs. 1, 2). It is oval, 104.5 m and 85.5 m long in N-S and E-W directions respectively, occupies an area of

Fig. 1. Bathymetrical map of Lakes Akaike and Ooike.
(Depth in meters).

* Geological Studies of Daitô-zima (Borodino Islands) by the Institute of Geology and Palaeontology, Tôhoku Imperial University, Sendai, Japan. Contribution No. 5.

1) H. Yabe and T. Sugiyama: Subfossil gizzard stones probably of birds found in the phosphate deposit of Kita-Daitô-zima. Proc. **10** (1934), 361-364; Sugiyama, T.: Boring in Kita-Daitô-zima. Contrib. Inst. Geol. Pal. Tôhoku Imp. Univ. in Japanese Language, No. 11 (1934). The island lies at 131° 17' E and 25° 57' N.

6080 sqm, is shallower than 2 m in its greater part, and fringed with luxuriant vegetation; the deepest point slightly hollowed out of the generally flat bottom measures 2.53 m. Its water was formerly reddish brown, hence the name Aka-ike, meaning red pond.

The monthly mean air temperature of the coldest month is 17.4° C, and the water temperature may hardly go lower than 15° C, even in the coldest day of the winter. On March, 1934, the water was transparent, the water temperature was 26.1° C at 6 pm when the air temperature was 24.0° C, and was 25.4° C at 11 am of the following day when the air temperature was 27.5° C.

Oo-ike, which lies west of the interior basin, is also fringed with dense growth of *Pandanus*. This oval lake is 132 m in diameter and 8790 sqm in area. Sugiyama's sounding revealed a flat bottom in which the deepest point measured 3.9 m. The water was turbid at the time of his visit (Fig. 1). Analysis of the waters from these lakes was made by the writer at the laboratory of the Geographical Institute of the College of Literature and Science, Tokyo (Table 1).

TABLE 1.

	Name of Lake	Akaïke	Ooike
	Total Residue	262.5	381.8
	Na'	52.5	71.4
	K'	5.6	—
	Ca''	12.3	12.4
	Mg''	7.5	11.5
	Fe	0.11	0.2
	SO ₄ ''	5.9	20.3
mg/l	CO ₂	16.9	21.9
	Cl'	104	141
	SiO ₂	4.9	4.9
	Consumption of KMnO ₄ 1)	30.5	61.0
	NH ₄ -N	0.09	1.2
	NO ₃ -N	0.36	0.08
	Albuminoid-N	0.37	0.7
	Soluble P ₂ O ₅ -P	0.00	0.00
	Total P ₂ O ₅ -P	0.01	0.001

The waters of both lakes reacted faintly acid (pH=6.4) and contained a considerable amount of salts, although they can still be classified as freshwater. The chief constituents were Na and Cl. The chemical composition very closely resembles that of sea-water, although the lakes lie 1.5 km from the sea; there are numerous limestone caves in the reef-building coral limestone of the passage extending from the interior central basin to the sea. Although the water is saline, the upper surface is fresh enough for drinking purpose. Notwithstanding that the salt from the sea finds its way into the interior basin, the heavy precipitation keeps the surface of these lakes quite fresh. From the fact that the organisms at the bottom are freshwater forms, it is possible that even the bottoms may not contain much salt. The clay

1) As digested in an alkaline medium.

Fig. 2. Akaike. Looking south, showing the hill covered with groves of *Pandanus tectorius*.
(Photo. T. Sugiyama).

that is thickly deposited around these lakes not only prevents the invasion of sea water, but also prevents the underground water of the central basin from flowing into them. In times of heavy storms, to which the island is frequently subject, sea salt is carried to the lakes by the salt winds.¹⁾

Contrary to the writer's expectation that these lake waters would contain much calcium and soluble phosphate on account of their being almost entirely built of limestone with hollows partly filled with phosphate deposits rich in alumina, the amounts of these two elements were not so large compared with other lakes of Japan. There is good reason to believe that the lakes fill basins in the limestone, whose bottom are thickly covered with brown clayey soil rich in humic material. A boring made on the shore of Lake Aka-ike indicated its thickness to be 2.68 m there, or 1.97 m below the lake level, the position of the boring being 0.71 m higher than the lake level. The bottom of the lake is probably also covered with thick mud, judging from the very deep muddy soil in some marshes in the central plain of the island. According to F. Yamanari, the soil of the central basin contains only a small percentage of calcium, which is washed away by the heavy precipitations owing to the porous character of the limestone below the soil.

Judging from the KMnO_4 consumed, and the nitrogenous compounds that are derived from the surrounding humic soil, the waters dissolve much organic matter. It is very probable that these lakes used to be

1) S. Yoshimura: The effect of salt-breeze on the chemical composition of freshwater lakes near the sea. Arch. f. Hydrob. **30** (1935), 345-351.

supplied with much calcium in former times, but the calcium in the soil was soon washed away by precipitations, resulting in the present dystrophic character of the lake. The gypsotrophy was succeeded by dystrophy. Such a succession of lake types has been described by Naumann¹⁾ with regard to the coastal lakes of southern Sweden.

Plankton was very abundant in both lakes; the samples collected comprise a blue alga, a few green algae, and many Rotifera, *Alona rectangula* and *Thermocyclops hyalinus*.²⁾

Of Mollusca, *Viviparus japonicus* is common, of fishes there are two species, *Cyprinus carpio* and *Carassius auratus*; these are common and recently introduced.

The bottom deposits contain a very large quantity of coarse detritus derived from land plants. S. Syôzi's analysis show the deposit of Oo-ike to contain 0.39% and that of Aka-ike 2.01% of CaO. The small amount of Ca corresponds to its poverty in the waters.

In the deposits of Aka-ike is found labium of a chironomid larva, belonging to *Chironomus plumosus*. Both lakes bottoms are probably inhabited by these insect larvae, which indicates the eutrophic character of the lake. Benthonic and planktonic diatoms are numerous and all belong to freshwater forms.

Generally speaking, Lakes Aka-ike and Oo-ike may be classified as a type between eutrophic and dystrophic, notwithstanding that they are located in the interior basin of an island of elevated coral limestone. The humic soil originally covered the present bottoms of water bodies and plays an important rôle in the limnology of the basin.³⁾

1) E. Naumann: Grundzüge der regionalen Limnologie. Die Binnengewässer 11 (1932), Stuttgart.

2) Another report in this concern will appear by M. Ueno. See p. 16 of this Proceedings.

3) I am grateful to Messrs T. Sugiyama and F. Yamanari for the limnological data and various informations, and also to Mr. S. Syôzi for his analyses of the bottom muds.