3. Proper Oscillations of Lake-shelves.

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We have previously¹⁾ shown that the long-period surface oscillations (of one to two hours) on the open sea-coasts, which have hitherto been unexplainable as seiches of neighbouring bays, must be attributed to the proper oscillations of shelf-seas. We proved also theoretically²⁾ that the oscillations of the shelf-sea can be dealt with in a manner similar to the way in which the oscillations of a bay are treated. We may expect that in a lake also, at the portion where the shelf is fully developed, oscillations of the same kind will occur. Actually, oscillations of about 5 min. period (Fig. 1) recorded during the Muroto typhoon by a limnimeter installed on the Imazu coast of Lake Biwa, can not be explained by any usual oscillating area forming a bay. One of the writers has suggested in another paper³⁾ that they will be oscillations of the neighbouring lake-shelf. According to this suggestion, the present work has been done. Since, in Lake Biwa, shelves develop most remarkably in the neighbourhood of Imazu and Ômizo and next in the vicinity of Kaizu, we made for ourselves soundings of these regions sufficiently minute for our present purpose, and calculated the periods of thus-obtained lake-shelves. On the other hand, we also made limnometric observations at these places and others, and determined the actual periods for each of the places. Comparison of the calculated periods and the observed will affirm the real existence of shelf-oscillations in the lake.

Soundings. The soundings in the neighbourhood of Imazu were

Fig. 1. Seiches at Imazu produced by the Muroto typhoon.

Fig. 2. Soundings in the Imazu-region.

1) Mem. Coll. Sci. Kyoto Univ., A, **18**, 247 (1935).

2) Ditto, **18**, 213 (1935).

3) Ditto, **18**, 227 (1935).

taken at 133 points along 12 observational lines, and near Ômizo at 153 points along 14 lines. By these data we constructed the depth-charts of each regions, only one of which is here reproduced in Fig. 2 as an example.

If we draw cross sections of the lake bottom according to the above charts, we see the distinct formation of the lake shelf, as shown in Fig. 3. Here, I_1 gives the bottom-relief of Imazu-region proper, being the mean of the nine cross sections corresponding to line a to i shown in Fig. 2, while I_2 is the mean for j to o -line, and I_3 represents the mean of all cross sections from a -line to o -line. Similarly, O_1 represents the mean section of the region of Ômizo proper, and O_2 the section of the next region north of O_1 . Lastly K -curve is obtained for Kaizu, using the depth-map given by the Kobe Marine Observatory.¹⁾

Seiche-observations.

Last autumn, at Imazu, Ômizo, Kaizu and other places we established non-reducing limnimeters of the bouy-type made in our own workshop, and made many records of seiches. We show only some examples in Fig. 4. From these records and the observations made by Dr. Nakamura and Honda²⁾ and also by the Kobe Marine Observatory,³⁾ we find several periods of seiches at these stations, as shown in Table 1.

Fig. 3. Cross sections at Imazu, Ômizo and Kaizu.

Fig. 4. Some records of seiches.

1, 3) 海洋氣象臺彙報, 8 (1926).

2) Seiches in some Lakes of Japan: Jour. Coll. Sci. Tokyo Imp. Univ., 28, Art. 5 (1911).

TABLE 1. Observed periods.
(thin type means weak rare occurrence)

Location	Observed period (in min.)				
Imazu	5	30	9	22	71
Ômizo	15	12	8-9	17-18	
Kaizu	9	30	11-12		

Oscillating areas. Now we shall examine the oscillating areas corresponding to the above observed periods. Let us first consider the ordinary areas of enclosed or bay type. As such for Imazu, there are the main body of Lake Biwa north of Katada, and the rectangular basin between Imazu, Siraisi-sima, Hikone, Nagahama and Kaizu. It is well known that the former has a period of about 70 min., and the latter should have a period of 30 min. for the longitudinal oscillation and 22 min. for the transversal. The remaining region conceivable as another oscillating area is only the inlet having the mouth at B_1 or B_2 line shown in Fig. 2. Calculating the period by the usual formula for bay with a mouth correction we get 10.3 min. if the mouth line is B_1 , and 8.9 min. if the mouth line is B_2 . Thus all the periods at Imazu except 5 min. have been explained.

Then, what is the nature of the 5 min. period? If we calculate the period (T) of the lake-shelf of Imazu, we will get $T_1=5.1$ min. for I_1 shelf and $T_3=5.3$ min. for I_3 shelf, answering the question clearly.

Similar calculations using Fig. 3 will show that the 15 min. period at Ômizo and 9 min. at Kaizu correspond to shelf-oscillations, and that the about 12 min. periods at both places are due to respective bay-oscillations, while the seiche of 30 min. at Kaizu is the same as the oscillation of the identical period at Imazu, and 17-18 min. at Ômizo corresponds to the oscillation of the middle part of the lake between the opposite shore (Yanagawa and Gogode, etc.), the 8-9 min. period being either its harmonics or the vibration of O_2 -shelf.

Conclusion. Summarizing the chief points stated above, we see that:

1) The oscillations of the lake shelf certainly exist, and that they have comparatively short periods among the lake-seiches.

2) Even in the bay of which the breath is larger than the length, oscillations seem to occur beyond our expectation; especially so when the bay is fan-shaped.

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