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# A STUDY ON THE FOAMING OF SEA WATER. PART 1

By

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In spite of the fact that many marine observers are aware that sea water has a remarkable foaming capacity, there has not been any scientific study of this subject. However, the foaming capacity may be of considerable importance in oceanography. For instance, there must be an intimate relation between the Beaufort scale and the foaming of sea water, since there is no doubt that aspects of white waves generated on the sea by winds largely depend on this effect.

It is known that a solution of inorganic electrolyte has a foaming ability, though weak and unstable. Therefore, the foaming nature of sea water may be due for the most part to inorganic material, and it is possible that organic substances such as humus also are important.

*The Degree of Foaming of Sea Water.* To obtain some degree of information regarding the foaming nature of sea water quantitatively, about 100 cc. of sea water were sealed in a glass ampule, foams were made by agitation with the hand, and the height of the foamy layer was then measured quickly. Since sea water foam is not stable, the height must be read as soon as the vibration has stopped. Pure sea water collected southeast of the Bonin Islands was used as a sample, after being filtered once.

The degree of foaming of sea water was compared with other organic liquid solutions such as ethyl alcohol. Results of measurements are given in Table I.

TABLE I—COMPARISON OF FOAMING OF SEA WATER WITH OTHER LIQUID SOLUTIONS

<i>Solution</i>	<i>Concentration</i>	<i>Height of foamy layer</i>
Butyl Alcohol	0.13 mol.	5.2 cm.
Amyl Alcohol	0.01 mol.	3.0 cm.
Ethyl Alcohol	0.1 mol.	2.2 cm.
Acetic Acid	0.8 mol.	1.8 cm.
Sea Water	Cl; 19.4 ‰	1.7 cm.
Artificial Sea Water	Cl; 19.0 ‰	1.2 cm.
Distilled Water	.....	0

As shown in Table I, the foaming of sea water is almost the same as that of an acetic acid solution of 0.8 mol., but it is weaker than that of 0.1 mol. ethyl alcohol solution. Distilled water shows no such foaming, which is well known. Since artificial sea water also produces foaming of the same order, a main cause of foaming may be attributed to dissolved inorganic salts. However, the foaming nature of artificial sea water is always weaker than that of natural sea water, so there must be some other causes for foaming which result from organic matters such as humus or dissolved gases.

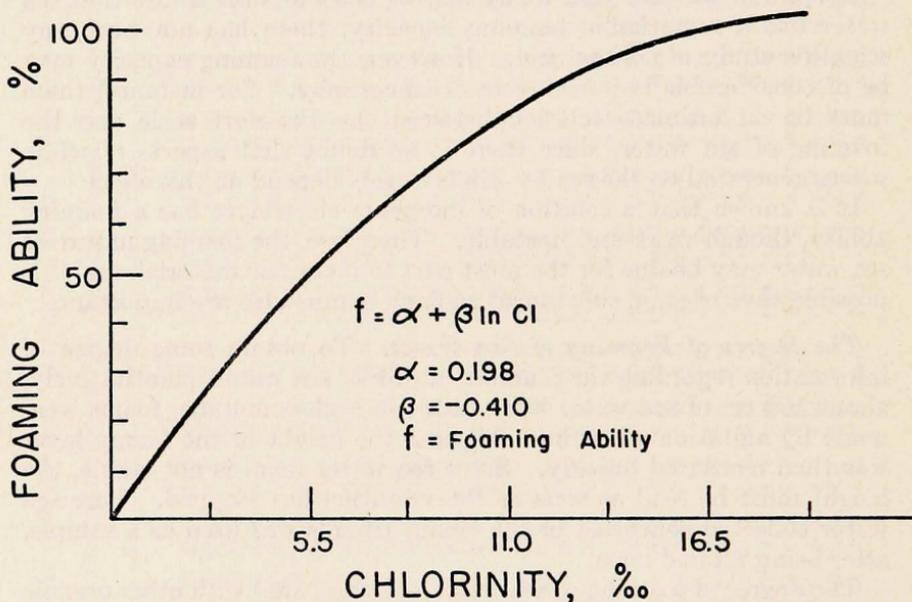


Figure 1. The relation between foaming and chlorinity.

It is also to be noted that foams of sea water are larger and more unstable than those of the solutions of organic compounds used for the comparison.

*The Relation between Foaming and the Chlorinity of Sea Water.* It is known that there is a relation between the foaming ability of electrolytic solutions and their concentration. In general, the degree of foaming increases with increasing concentration, and in some cases, it reaches a maximum at a definite concentration. We studied this point for sea water and obtained the results shown in Fig. 1.

In Fig. 1, relative height of the foaming layer (*i. e.*, relative foaming

ability) is given. As shown, the height of the foamy layer decreases exponentially with decreasing chlorinity. The empirical relation between the foaming layer and the chlorinity is as follows:

$$f = \alpha + \beta \ln Cl,$$

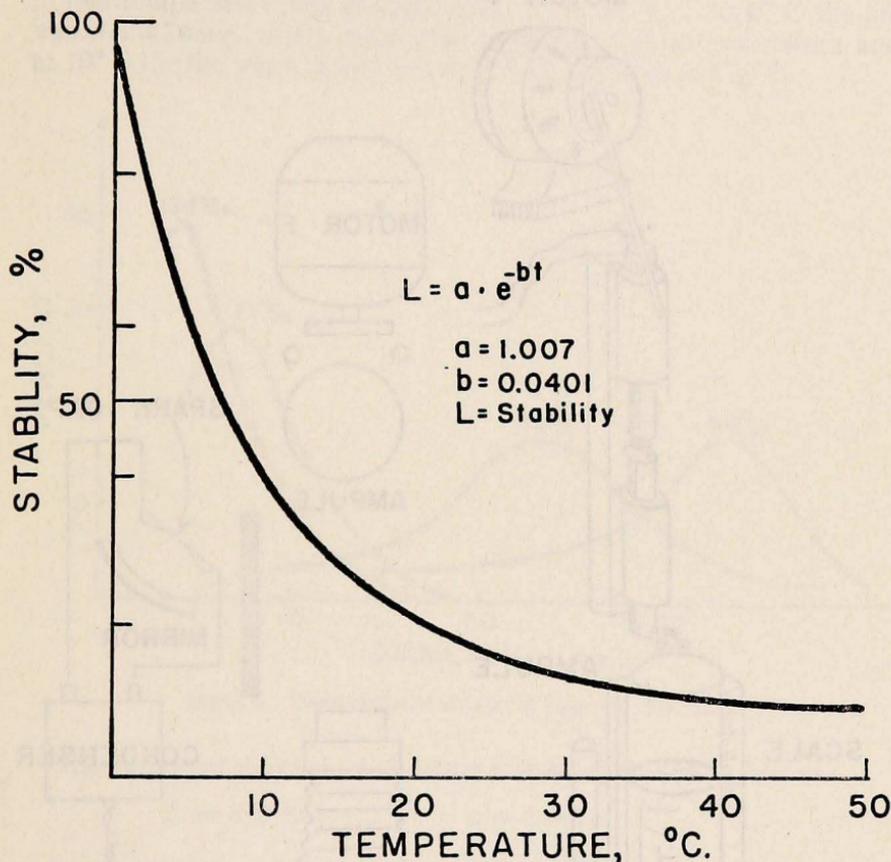


Figure 2. The relation between stability and temperature.

where  $f$  is foaming capacity (relative height of a foamy layer, sea water having  $Cl$  19.4 ‰ as a standard), and  $Cl$  the chlorinity of sea water;  $\alpha$  and  $\beta$  are constants. This formula shows that the foaming ability is proportional to the natural logarithm of the concentration of sea water.

Since the chlorinity of water with a half value of foaming ability is about 5 ‰, it can be said that the foaming capacity of sea water offshore is practically the same everywhere.

*The Relation between the Stability or Life of Foams and the Temperature of Water.* The temperature effect on foamy layers was studied next, and it was found that the temperature had a great influence on

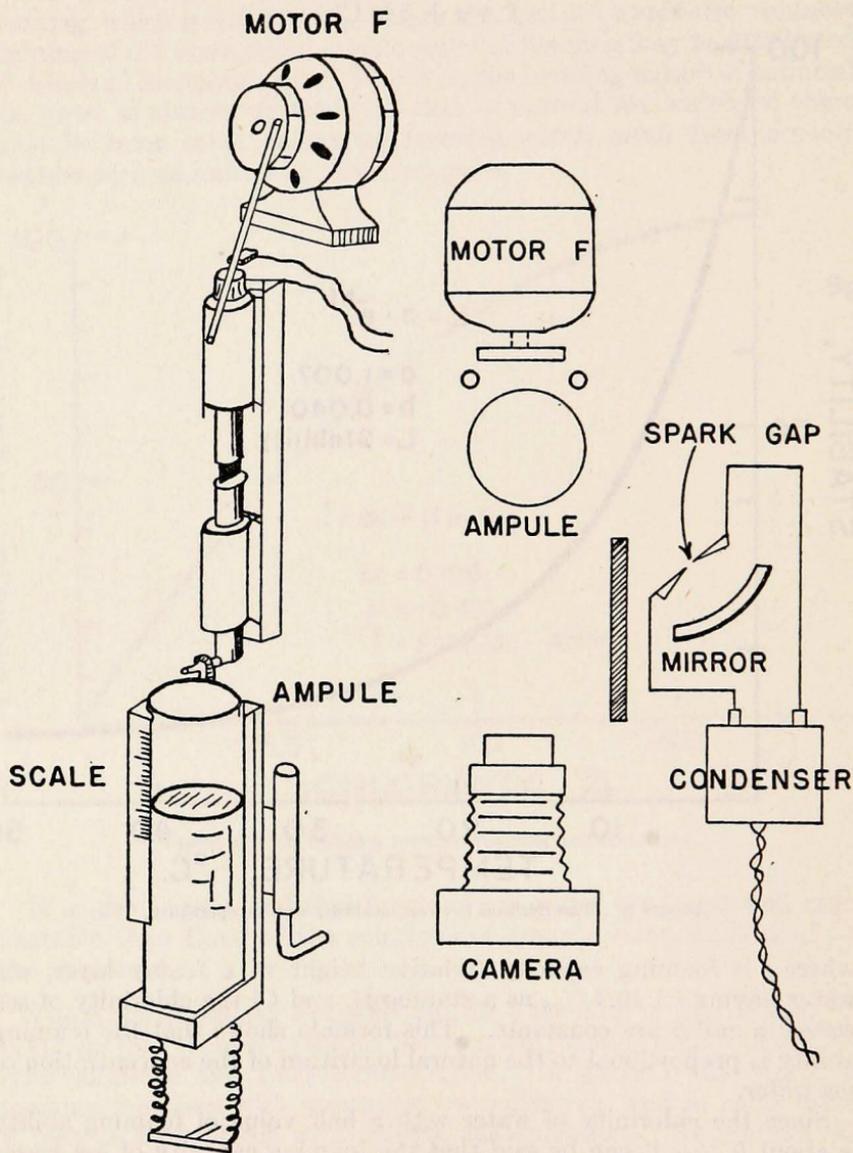


Figure 3. Diagram of apparatus.

the life of the foamy layer, but had little effect on the amount formed.

As shown in Fig. 2, the stability of a foamy layer (*i. e.*, the time of duration of the foamy layer after the vibration has stopped) has an intimate relation with the temperature of water.

The temperature was changed from 0° to 50° C. At 0° C the life was about 70 sec., it became shorter as the temperature was raised, and at 10° C the life was reduced to about half, as shown in Fig. 2.

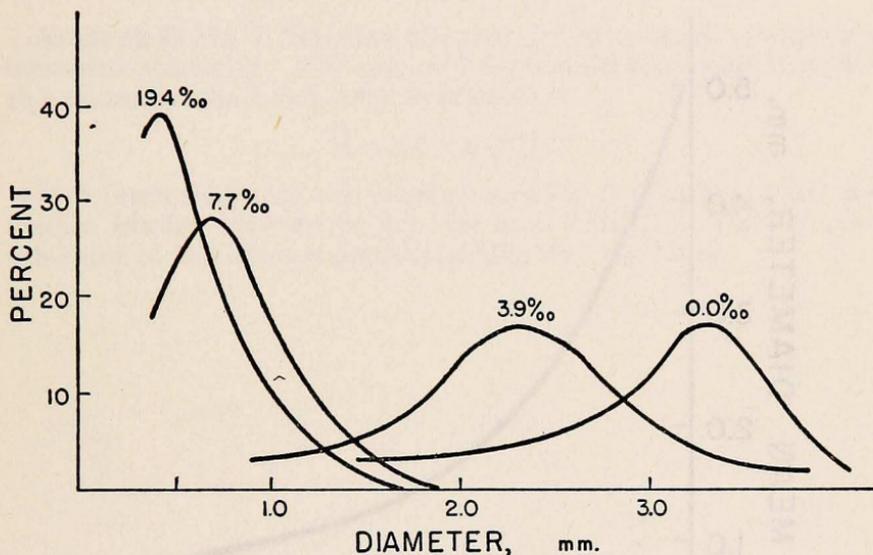


Figure 4. Distribution of the size of foam and chlorinity.

The empirical relation of stability and chlorinity is as follows:

$$L = a \cdot e^{-bt} \quad \begin{array}{l} a = 1.007, \\ b = 0.0401, \end{array}$$

where  $L$  is the relative life (sea water having the chlorinity 19.4 ‰ as a standard),  $t$  the temperature, and  $a$  and  $b$  constants.

*The Size of Foams.* The measurement of the size of each foam bubble was obtained by means of the apparatus illustrated in Fig. 3. A photograph of the foamy layer was taken with illumination from a spark between two electrodes of aluminium.

A glass ampule was vibrated up and down by a motor (F) about fifteen times per second. As soon as the vibration ceased, a spark was flashed and a photograph was taken on a plate, which was then en-

larged and the size measured directly on the plate with a pair of dividers. Thus, the size of each bubble could be given with an accuracy of 0.2 mm. Results of measurements are shown in Fig. 4.

As shown, the distribution of size for a definite concentration forms nearly a normal distribution curve. The peak of the curve becomes lower with decreasing chlorinity, and at the same time it becomes broader.

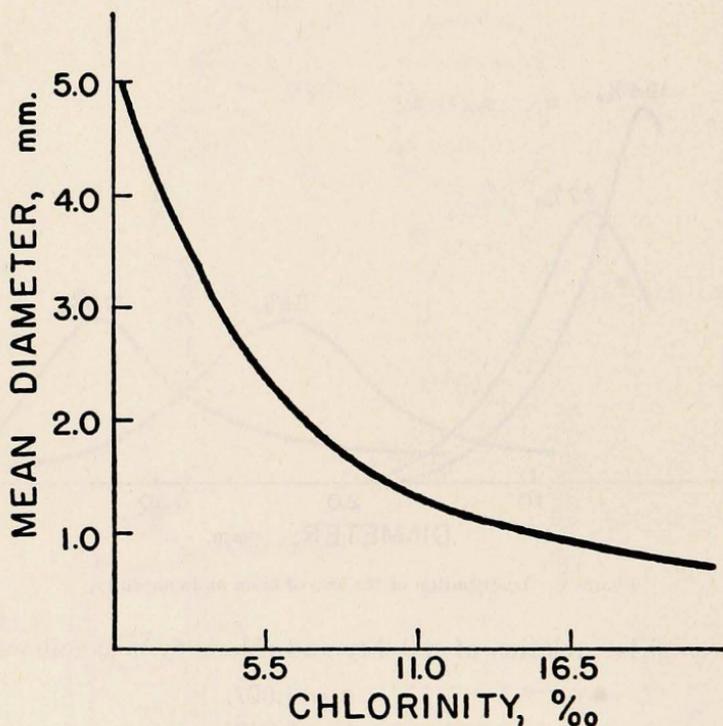


Figure 5. The relation between a mean diameter and chlorinity.

In Table II, mean diameters of bubbles for different chlorinity concentrations are given. Mean diameter  $\bar{d}$  was calculated by the following formula:

$$\bar{d} = \sqrt[3]{\frac{\sum d^3}{\sum n}},$$

where  $d$  is a diameter of each bubble and  $n$  the number.

TABLE II—THE CHLORINITY AND MEAN DIAMETER OF FOAM (BUBBLE)

<i>Mean diameter</i>	<i>Chlorinity</i>
0.75 mm	19.0 ‰
0.84 mm	17.4 ‰
0.98 mm	15.9 ‰
1.19 mm	7.7 ‰
2.74 mm	3.9 ‰
5.11 mm	0.0 ‰

As shown in Fig. 5, the mean diameter decreases exponentially with increasing chlorinity. The empirical relation between mean diameter and chlorinity was found to be as follows:

$$\bar{d} = 5.4 \times 8.5^{-c^i}.$$

It is interesting that the foaming capacity is correlated with the inverse relation between bubble size and chlorinity. Further consideration of this effect is contemplated in the near future.