Interstitial Waters of Recent Marine Muds Off Cape Cod

Abstract. Interstitial waters of Recent muds off Cape Cod have salinities higher than the present ocean water in the same location and *p*H values lower than normal sea water in equilibrium with the atmosphere. The salinities may be either "paleosalinities" or an effect produced by behavior of the clay-water system as a semipermeable membrane. The low *p*H values are due to higher pressures of CO_2 in the sediment, probably coming from bacterial decomposition of organic matter.

On a recent cruise of the research vessel *Atlantis* of the Woods Hole Oceanographic Institution, several piston cores of bottom muds were taken and "squeezed" to remove the interstitial water. The stations occupied were all in the vicinity of 41°55′N, 69°30′W, in a small area of Recent grey muds several miles off Nauset light on the outer part of Cape Cod. Two layers were penetrated, a section of grey, slightly silty homogeneous clay, 1 to 6 m thick, at the top, and a section of brown and grey sandy and pebbly clay, at least 2.5 m thick, below. The upper grey clay contains a few marine mollusk shells, and is estimated to contain 2 to 5 percent $CaCO_3$. The lower brown sandy clay contains many carbonaceous fragments. Tentatively, the lower zone is correlated with the late Pleistocene, and the upper with the Recent. An oxidized transition zone of about 30 cm separates the two zones.

Samples of the cores were squeezed in a modified filter press of special design (*1*) to extract the interstitial water. The Na^+ activity of these waters and the bottom sea water, hereafter called "sodium-ion," were measured by a Na^+ sensitive glass electrode. This electrode should have no interference by other ions in sea water or interstitial water (*2*). Differences of electromotive force between standard Copenhagen water and the unknowns were read to ± 0.05 mv; it is estimated that the ratios reported are accurate to ± 1 percent of the number given. Chlorinity of the same samples was determined by $AgNO_3$ titration (Knudsen method). In addition, some *in situ* measurements of sodium-ion were made by pushing the glass electrode into the soft sediment. The values of sodium-ion determined by direct *in situ* measurement and by determinations on the squeezed waters are much the same.

Sodium-ion and chlorinity of bottom sea water and interstitial water plotted against depth in one core is shown in Fig. 1; the values are given as ratios to standard Copenhagen water (chlorinity = 19.374). The bottom water in this area is considerably less saline than that of the normal open sea throughout the year, mainly because fresh water funnels out of the Gulf of Maine past Cape Cod. The interstitial waters are all higher in sodium-ion and chlorinity than the overlying sea water, but less than Copenhagen water. The $\text{sodium-ion}_{sample}/\text{sodium-ion}_{standard}$ and $\text{chlorinity}_{sample}/\text{chlorinity}_{standard}$ ratios are in good agreement except for the bottom sea water, in which the $\text{sodium-ion}_{sample}/\text{sodium-ion}_{standard}$ is appreciably lower than the $\text{chlorinity}_{sample}/\text{chlorinity}_{standard}$.

The salinity change between bottom water and interstitial water may be explained by one of two alternatives. One is that some process is operating that is concentrating the salts in the sediment as the water of compaction is expressed upwards. It may be considered that the compacting clay-water system acts as a semi-permeable membrane, and only water is expressed, the hydrated ions being held behind.

An alternative is that this water is trapped unmodified sea water, and the salinities are "paleosalinities" (*3*). If this were so, it would suggest that the sediments accumulated in the past, when the hydrographic situation affecting sea water composition was somewhat different than that of today. For example, the sediments might have been accumulating during a time of decreased precipitation that resulted in less fresh water dilution from the Gulf of Maine than at present.

The choice between these alternatives can be made more easily after the completion of studies in progress on the behavior of clay-water systems under pressure as semi-permeable membranes and after more oceanic sediments are sampled to see if the effect is general or restricted to this area.

Determinations of *p*H by ordinary glass electrode were made *in situ* and on the expressed interstitial waters. The results showed that the *in situ* *p*H ranges from 7.4 to 7.8, whereas in the interstitial waters which were aerated in the squeezing process, it ranges from 8.1 to 8.2, a figure one would normally expect from sea water in equilibrium with the atmosphere. The simplest explana-

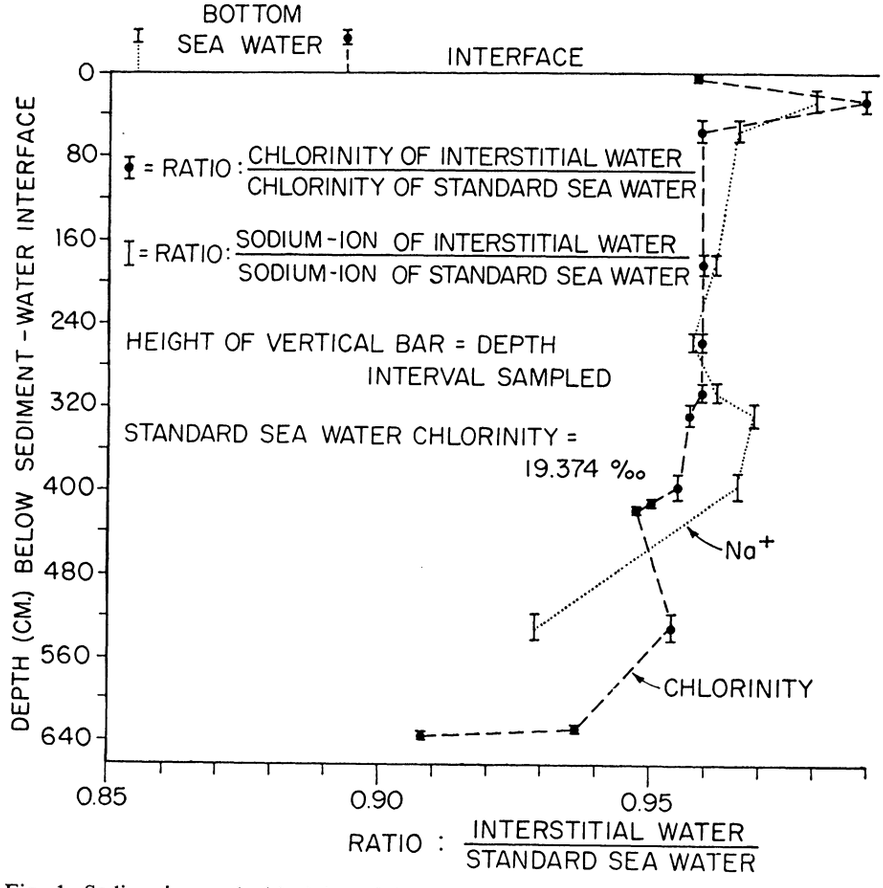

Fig. 1. Sodium-ion and chlorinity of bottom sea water and interstitial water plotted against depth.

tion for this discrepancy is that the CO_2 pressure in the sediment is higher than that in equilibrium with the atmosphere, and it is this that keeps the *p*H down. A calculation of the CO_2 pressure based on the *p*H change indicates that CO_2 pressure in the sediment is almost ten times that of the atmosphere. Measurements with a glass electrode, with a saturometer technique (*4*), indicated that the *in situ* sediment water is saturated with respect to $CaCO_3$ (calcite). The increased CO_2 is most likely the result of bacterial oxidation of organic matter. If this is so, CO_2 apparently diffuses upward through the sediment too slowly to allow the sediment to equilibrate with the overlying sea water, which, at this location, is almost certainly close to equilibrium with the atmosphere. Saturation with respect to calcite indicates that the solid carbonate shells are quick to equilibrate with the increased CO_2 by dissolving slightly (*5*).

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Spontaneous Ejaculation in Rat

Abstract. Daily seminal discharges were observed when individually caged male rats were prevented from grooming the genital region orally.

Seminal ejaculation in the rat is believed to depend upon genital stimulation derived from a series of intromissions (*1*). Few observations have been made of ejaculation in the absence of penile stimulation. Aronson (*2*) observed erection and ejaculation during sleep in the domestic cat. But these events were often accompanied by pelvic movement. We have recently observed spontaneous ejaculations in hooded and albino rats after bilateral damage to amygdala and hippocampus primarily, but also after damage to septum, olfactory bulb, hypothalamus, and cortex (*3*).

Table 1. Daily ejaculations and penile smears of ten albino rats.

Animal	Seminal plugs/days of observation		Penile smears		
	Rats unrestrained	Rats girdled	Percent of 11 smears, taken during daylight, containing sperm; rats unrestrained	Presence of sperm in one smear taken nocturnally; rats unrestrained	Presence of sperm in one smear taken during daylight; rats girdled
5	2/20*	3/1	9	Yes	Yes
11	0/20	1/1	18	Yes	Yes
14	1/20	1/1	36	Yes	Yes
16†	27/20‡	2/1‡	0	No	No
17	1/20*‡	2/1	82	Yes	Yes
18	0/19	4/2	45	Yes	Yes
21	1/19‡	4/2	45	Yes	Yes
27	5/20	2/1	0	Yes	Yes
30	0/20	1/1	73	Yes	Yes
31	0/18	3/3	82	Yes	Yes

* Plugs were partly visible at the penis and were removed with forceps. † In this rat, each testis was about one-quarter the normal weight. Microscopic examination revealed no evidence of spermatogenesis. ‡ No sperm were found on microscopic examination.

The unoperated rat reveals a similar though lower incidence of spontaneous ejaculation. The data are based upon daily counts of seminal plugs deposited on the service pan which was lined with paper toweling. These plugs, consisting of coagulated semen, were verified microscopically, and the presence or absence of sperm was noted. Ten albino rats obtained from the National Institutes of Health were observed over a 21-day period. These rats were sexually mature and weighed 220 to 260 g. Four were caged in pairs, and the remaining six were caged individually. The differences in caging had no differentiating effects, and the data for all ten rats are presented in Table 1.

Six of the ten rats deposited at least one seminal plug during the period of observation. One rat, No. 16, deposited no less than one plug each day. This rat had inordinately small testes, each weighing 0.35 g, and there was no histological evidence of spermatogenesis. Microscopic examination of the plugs revealed that four rats had little or no sperm in their plugs (including No. 16), while the other six had plugs which were full of sperm.

Penile smears of the ten rats, taken on 11 successive days during daylight hours, were examined microscopically. The smears were prepared by passing a glass slide across the end of the exposed penis. In eight rats, sperm was indentified in at least one smear. Nocturnal smears, however, all contained sperm with the exception of the smear from rat No. 16. This led us to believe that all rats must have spermatic discharges quite frequently and that the lack of positive penile smears during daylight hours must be due to oral grooming of the genital region. Coupled with this, the more frequent deposition of plugs by the rats with brain lesions suggested that a seminal discharge might be occurring periodically in all rats, unoperated as well as operated, and that the more fastidious rats, the unoperated ones, tend to remove the evidence by oral grooming.

To test this hypothesis, we restrained the ten rats from grooming. Each rat was encased in a plastic tube which served as a stiff girdle around the thorax and abdomen, thus preventing the rat from bending to groom the genital region orally. Table 1 shows that the girdled rats deposited at least one seminal plug each day. All plugs contained sperm except those of No. 16. Under similar restraint, a single penile smear taken during daylight revealed a positive smear in all rats, again excepting No. 16. In order to rule out mechanical stimulation by the girdle as a factor in ejaculation we muzzled rats with adhesive tape and found a similar frequency of plugs. Our hypothesis that all rats have spontaneous daily seminal discharges, and that they frequently groom away the evidence, was thus confirmed (*4*).

We have made similar observations on two additional colonies of rats under unrestrained conditions. Seventy-six Sprague-Dawley rats were observed over a 10-day period with confirmatory results. Sixteen rats deposited at least