RADIOCARBON DATING OF SALT WATER FOUND IN WELLS DRILLED INTO THE BEDROCK IN THE COASTAL AREA OF FINLAND

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Radiocarbon determinations of salt water drawn from some deep wells drilled into the bedrock confirmed the earlier suggestion that this ground water with a high chloride content is relic water from the time in the development of the Baltic when the coastal areas of Finland were submerged. An exact date cannot be given for the salt water because it has later been mixed with younger ground water.

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In some parts of Finland the ground water in wells drilled into the bedrock has a rather high chloride content (Laakso 1966). The greatest reported content was in a well at Ylistaro, in the county of Vaasa, where water collected at 600 m depth had a chloride content of 6 300 mg/l (Laakso 1966). It has been suggested (Salmi 1963; Lahermo 1971) that this water is relic saline water from the time of the Holocene marine stages of the Baltic when the coastal areas of Finland were submerged. This is supported by the fact that the chloride content decreases if much water is drawn from a well with salt water. In an attempt to obtain further evidence about the origin of the salt water the authors performed a radiocarbon dating of the water from some drilled wells, listed in Table 1. The bedrock at the surface consists, at Aura of mica gneiss and kinzigite, at Rautio of quartz diorite and granodiorite, and at Alavieska of feldspar-bearing mica schist, basic plutonic rock and basic porphyrite. Thus, there is probably no great influence on the ages from dissolved carbonates. In order to control this possibility a pair of wells was chosen in each area, one with salt water and another less deep well with freshwater. The distance between wells I and II in Aura is about 1 km while it is 11 km between wells I and II at Rautio and Alavieska in Pohjanmaa.

The samples were collected in 1972. The water was pumped into airtight HD-polyethylene containers and transported to the laboratory, where the CO_2 was released with HCl. This was done under a pressure of about 100 mm and the concentrated HCl was slowly added at the same time as the sample was mixed and heated to the boiling

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Sample and location	δC ¹⁴	δC ¹³	Δ	Age	Altitude and depth of well
Hel-266, Aura I 60°38′30″N, 22°35′30″E	-393±15		-401±16	4 010 ± 210	c. 40 m a.s.l., depth 136 m
Hel-288, Aura II 60°38'30"N, 22°36'E	-194±16	-20.5	-201±17	1730±160	c. 40 m a.s.l., depth 43 m
Hel-281, Rautio, Pohjanmaa I 64°05'N, 24°12'E	-315±10		-329 ± 11	3 030±120	55 m a.s.l., depth 113 m, 15 m of clay on top of the bedrock
Hel-282, Alavieska, Pohjanmaa II 64°11'N, 24°12'E	-161±16	17.7	-173±17	1 410±150	40 m a.s.l., depth 101 m, 6 m of clay on top of the bedrock

TABLE 1

TABLE	2
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	pH	Calcium (Ca)	Chloride (Cl)	Natrium (Na)	free CO ₂	HCO3
Aura I	7.7	110 mg/l	245 mg/l	74 mg/l	13.2 mg/l	200 mg/l
Aura II	7.6	59.5	128	9.1	7.1	250
Pohjanmaa I	7.9	530	1 270	380	9.2	300
Pohjanmaa II	8.0	26.0	120	180	1.8	250

point. The yield of CO₂ gas per 100 l of water was c. 4 l (NTP). The collected CO₂ gas was then treated in the normal way. Because of a rather high radon-content the samples were stored c. 3 months before they were counted. The determinations of δ C¹³ were done by Dr. R. Ryhage at the mass-spectrometric laboratory of the Karolinska Institute, Stockholm. The results are given in Table 1. The results of the chemical analyses are given in Table 2.

The ages of c. 1 500 years for Aura II and Pohjanmaa II are reasonable for ground water at the depths of about 40 m. Both at Aura and Pohjanmaa sample I is older than sample II. There is, however, no clear relationship between the chloride content and age. The δC^{13} values are also in both cases lower in samples I. But they must both be considered to be mixtures of older salt water and younger ground water. The low values of the chloride content as well as the δC^{13} values suggest that the salt water only forms a small part of this mixture. Therefore a more accurate estimate of the age of the salt water cannot be made. The results, however, support the assumption that the occurrences of salt water are relics from the Holocene marine stages in the Baltic. The present chloride content has, for instance, in the Baltic at Edenäs, Utö, been determined to 3 440 mg/l and at Harö in the Bothnian Sea to 2 924 mg/l (Ericsson 1973).

According to the geological datings of the emergence of the west coast of Finland, Aura at 40 m a.s.l. became dry land c. 5 500 years ago and Pohjanmaa at 55 m a.s.l. c. 4 000 years ago. This was at the time of the Litorina Sea stage which began c. 7 500 years ago when the salinity was greater than in the present Baltic.

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Appendix

At the same time as the above-mentioned determinations were made the water used by the Porvoo waterworks was dated. In this water chloride contents up to 450 mg/l were recorded during a short period of 1972. The water used was pumped from the Porvoo river into a reservoir, from which it filtered through the esker by the river to the wells at the waterworks. The results from the dating of the water used at the waterworks (Hel-340) and water taken from the surface of the Porvoo river are given in Table 3. They show that the salt water is not in this case old water. Later investigations of the

TABLE	3
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Sample	δC ¹⁴	Age	Chloride (Cl)
Hel-340, Porvoo I	-44±16	350±120	340 mg/l
Hel-358, Porvoo II	$+44{\pm}14$	Recent (45

ground water occurrences in the area showed that the salt water was sea water, which had penetrated up the river during a period when the outflow was small.

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