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Hydrochemistry of water basins on raised marine terraces in the lower part of Ebbadalen, Billefjorden, central Spitsbergen

ABSTRACT: During a month from 28 June till 27 July 1987 measurements were made of variations in the chemical composition of shallow water basins occurring on the north side of the Ebbaelva gap section at the southwestern foot of Løvehovden. The waters have variable mineral contents and ion composition. The resulting data indicate a marked effect of various kinds of water feeding the basin, including water derived from the melting of snow and that released due to permafrost degradation, depending on bedrock and the intensity of biogenic processes which operate in areas of basin occurrence.

Key words: Arctic, Spitsbergen, hydrochemistry.

Introduction

On the north side of the Ebbaelva gap section at the southwestern foot of Løvehovden occurs an extensive raised marine terrace of 14—16 m a.s.l. It consists of two or three storm ridges and the intervening conspicuous overflowing hollows occupied by water basins and extremely wet sheets of deposits resulting from the organic-mineral accumulation. Water basins and marshes are formed as a result of the melting of snow and summer degradation of permafrost. Seasonal thawing penetrates inwards to the depth of 0.9 m. During the short Arctic summer shallow water basins undergo reduction in surface area to become replaced by extensive marshes. Only the deepermost hollows are occupied by isolated water basins which become totally frozen in early winter.

The surface of the area where the basins occur is composed of gravelly-

-sandy deposits resulting from marine accumulation. Their thickness is variable, ranging from several centimetres to a few metres. Their diversified palaeosurface is built up of glacial deposits, presumably due to recession at the Billefjorden Stage on the one hand and solid rocks displaying varying degrees of weathering on the other hand.

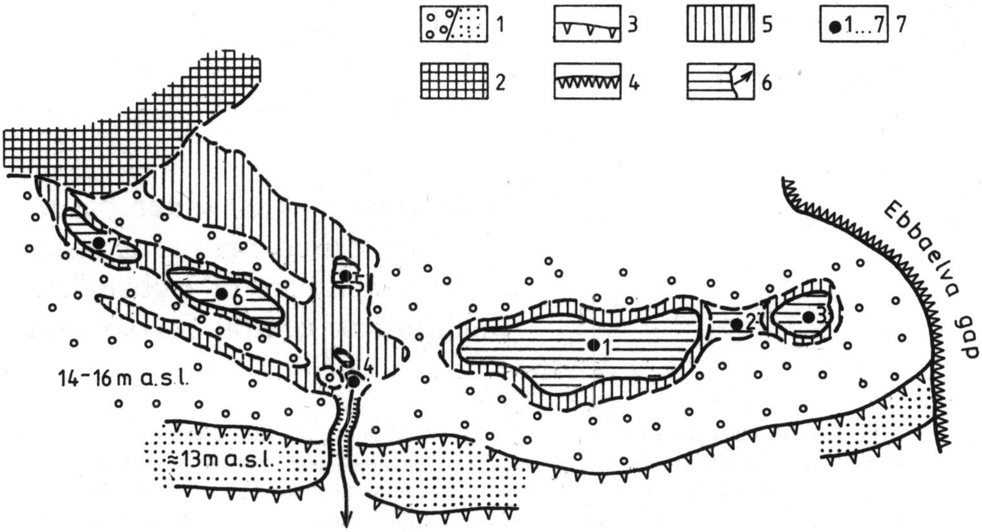

Fig. 1. Sketch-map of sites under investigation
1: marine terraces, 2: solid rock outcrops with solifluction covers, 3: marine terrace scarps, 4: erosional edge of Ebbaelva gap, 5: marshes and peatbogs, 6: water basins and streams, 7: water sampling sites

During a month from 28 June till 27 July 1987 the chemical composition of the water basins under investigation was determined. The sketch-map of sampling sites is shown in Figure 1. The waters of a basin located between debris-morainic ridges at the foot of Løvehovden were also analysed for chemical constituents. The basin lies at an altitude of about 80 m a.s.l. at a distance of about 400 m to the north of the main study area. The sketch-map showing its location is given in Figure 4.

The chemical composition of water was analysed immediately at the base station. Analytical techniques included determinations of hydrogen ion concentration, specific conductivity, calcium and magnesium ion concentrations, as well as bicarbonate, carbonate, sulphate and chloride ion concentrations (Minczewski and Marczenko 1985, Markowicz and Pulina 1979). The sum of sodium and potassium ions results from a difference between the amount of calcium and magnesium anions and the sum of cations. The determination of the concentration of sodium and potassium ions in a few selected samples delivered to the laboratory of the Quaternary Research Institute and investigated by the use of flame photometry allowed approximate quantitative sodium-potassium ratios to be established.

Research results

The water basins occupying a relatively small area have variable mineral contents and differ in quantitative ion composition. The resulting data are presented in the table and Figures 2—4.

The waters of adjacent basins 1, 2 and 3 are termed as bicarbonate--calcium waters (Fig. 2). Site 1 is characterized by low mineral contents which increased slightly throughout the observation. It is a relatively large water basin fed chiefly by snowmelt and water resulting from the summer degradation of permafrost but the snowmelt predominates.

Adjacent water basins 2 and 3 which were shallower and smaller in surface area became reduced throughout the observations until they disappeared completely. Their mineral contents increased intensely and markedly with time, *i.e.* throughout two-week observations. Particularly intense was an increase in calcium, bicarbonate and sulphate ions.

Basins 5—7 filled with calcium-sulphate-bicarbonate waters with markedly higher mineral contents, compared with the waters at sites 1, 2 and 3 (Fig. 3, Tab. 1). Throughout the observations mineral contents increased. Particularly intense was a rise in sulphate and calcium ion concentrations. During one-month observations the waters in basin 5 changed from calcium-bicarbonate-sulphate waters into calcium-sulphate-bicarbonate waters.

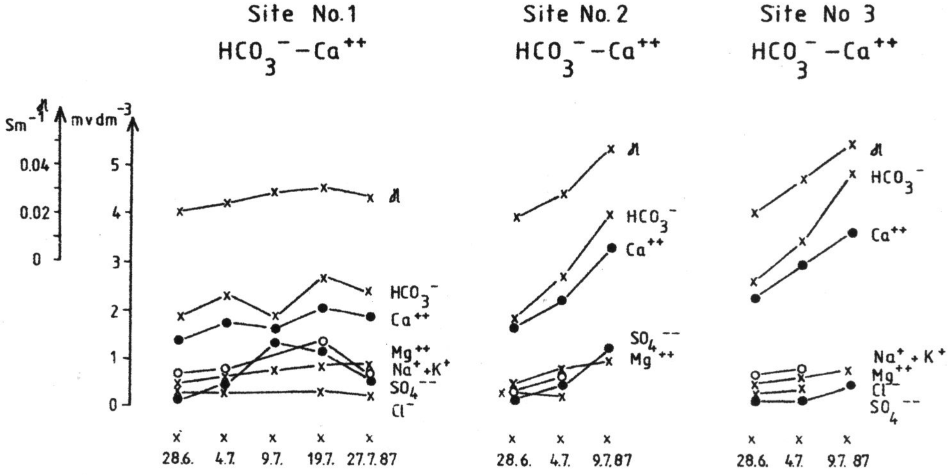

Fig. 2. Variations in ion composition and specific conductivity of water at sites 1, 2 and 3

Table 1

Hydrochemical characteristics of water basins in the Ebbaelva

Site	Sampling date	Air temperature °C	Water temperature °C	pH	κ25°C Sm^{-1}	Anions $mvdm^{-3}$				Cations $mvdm^{-3}$		
						CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Others
1	28.06.87	4.5	8.6	7.6	0.021	0.0	1.90	0.44	0.20	1.38	0.50	0.66
	04.07.	2.4	6.0	8.2	0.025	0.0	2.35	0.38	0.48	1.72	0.70	0.79
	09.07.	9.0	13.0	8.7	0.030	0.5	1.82	—	1.36	1.70	0.94	—
	19.07.	5.9	7.2	8.3	0.031	0.0	2.75	0.40	1.24	2.06	0.98	1.35
	27.07.	2.2	6.0	7.3	0.028	0.0	2.45	0.43	0.64	1.94	0.86	0.72
2	28.06.87	4.5	11.8	8.3	0.021	0.3	1.80	0.40	0.28	1.78	0.50	0.50
	04.07.	2.3	6.4	8.4	0.031	0.3	2.80	0.41	0.48	2.32	0.96	0.71
	09.07.	9.0	15.4	8.4	0.050	0.5	4.15	—	1.36	3.44	1.18	—
3	28.06.87	4.5	11.1	8.5	0.024	0.3	2.80	0.38	0.28	2.42	0.56	0.78
	04.07.	2.3	6.4	8.5	0.038	0.5	3.55	0.46	0.32	3.06	0.86	0.91
	09.07.	9.0	16.0	8.1	0.053	0.0	5.00	—	0.60	3.80	1.00	—
4	28.06.87	4.5	10.0	8.2	0.050	0.0	3.25	0.34	1.46	3.90	0.88	0.27
	04.07.	2.4	5.0	7.9	0.053	0.0	3.35	0.32	2.70	4.38	1.12	0.87
	09.07.	8.0	14.0	8.1	0.064	0.0	3.60	—	3.66	4.68	1.18	—
	19.07.	6.0	7.0	8.2	0.055	0.0	3.40	0.39	2.96	4.42	1.18	1.15
	27.07.	3.0	6.0	7.6	0.053	0.0	3.10	0.37	3.10	4.60	1.20	0.77

5	30.06.87	4.0	10.0	8.0	0.046	0.0	2.90	0.29	2.20	3.94	0.94	0.51
	04.07.	2.2	5.2	7.8	0.051	0.0	3.15	0.28	2.80	4.10	1.30	0.83
	09.07.	10.0	16.0	8.1	0.063	0.0	3.60	—	4.16	4.48	1.20	—
	19.07.	6.2	7.0	8.2	0.060	0.0	3.55	0.39	3.00	4.94	0.96	1.04
	27.07.	3.0	5.6	7.8	0.059	0.0	3.35	0.40	4.04	5.20	1.74	0.85
6	30.06.87	4.0	11.0	8.1	0.045	0.0	2.40	0.30	2.46	3.82	0.98	0.36
	04.07.	2.1	5.8	7.9	0.050	0.0	2.60	0.25	3.36	4.08	1.20	0.93
	09.07.	9.0	17.4	8.2	0.070	0.0	2.70	—	3.32	5.04	1.08	—
	19.07.	5.9	7.1	8.3	0.067	0.2	2.70	0.29	4.00	5.94	0.56	0.69
	27.07.	3.0	2.4	7.7	0.050	0.0	2.65	0.38	3.62	4.30	1.66	0.69
7	30.06.87	4.0	10.0	7.9	0.038	0.0	2.10	0.25	1.98	3.26	0.66	0.41
	04.07.	2.0	4.6	7.6	0.049	0.0	2.35	0.26	3.64	4.20	1.28	0.77
	09.07.	9.0	15.0	8.2	0.068	0.0	2.60	—	4.10	4.94	1.20	—
	19.07.	6.3	6.9	8.2	0.068	0.0	3.05	0.27	4.50	6.10	1.00	0.72
	27.07.	3.0	4.4	7.7	0.067	0.0	2.70	0.29	5.40	6.60	1.20	0.59
8	30.06.87	4.0	3.4	7.7	0.016	0.0	1.90	0.15	0.22	1.20	0.78	0.29
	04.07.	1.8	2.7	7.1	0.017	0.0	2.05	0.20	0.80	1.20	1.20	0.65
	09.07.	8.0	2.2	8.2	0.019	0.0	2.00	—	0.82	1.36	0.50	—
	19.07.	6.0	2.8	8.0	0.016	0.0	1.85	0.22	0.42	1.24	0.58	0.67
	27.07.	2.2	2.8	7.7	0.024	0.0	2.40	0.25	1.06	1.80	0.96	0.95

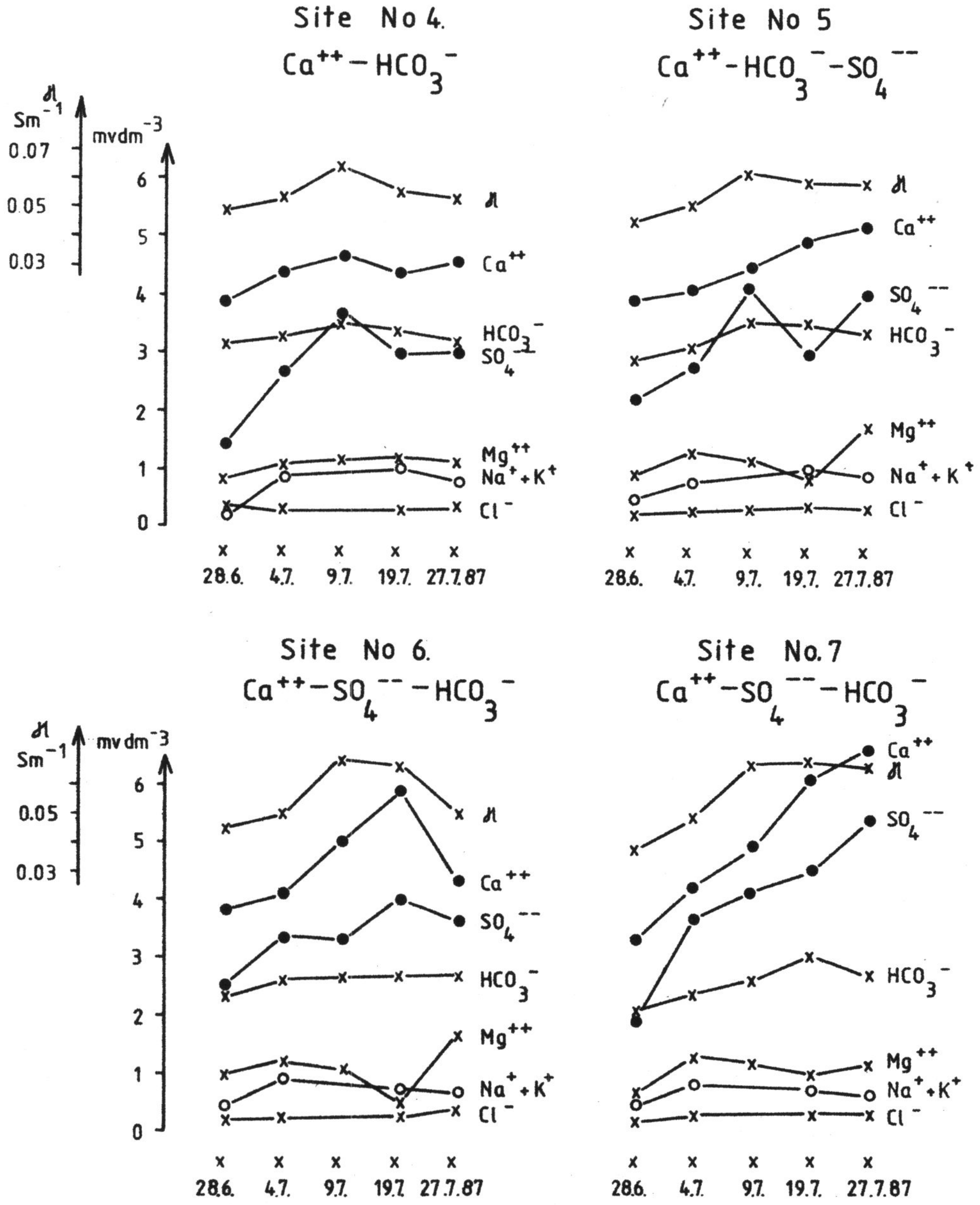

Fig. 3. Variations in ion composition and specific conductivity of water at sites 4, 5, 6 and 7

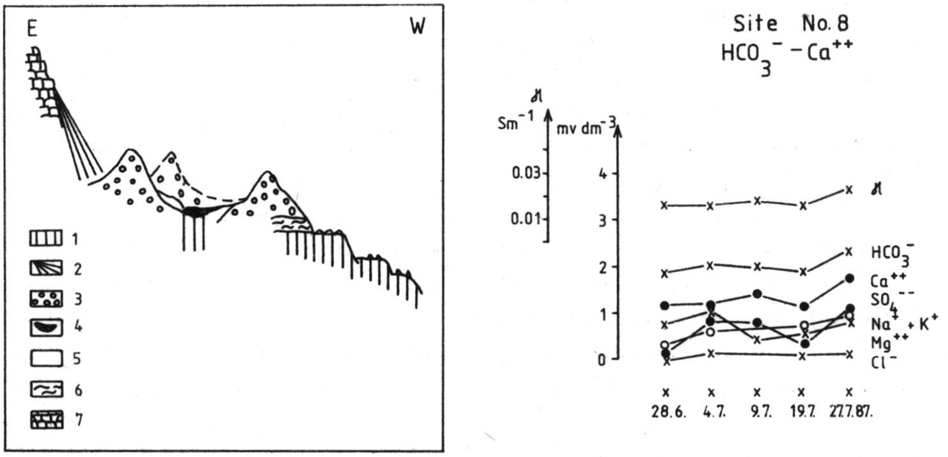

Fig. 4. Sketch-profile of water basin 8 and variations in ion composition and specific conductivity of water in the basin
1: gypsum, 2: cones, 3: debris-morainic ridges, 4: water basin, 5: snow patch, 6: till cover, 7: limestone and sandstone

Site 4 is located at the point that water flowing from marshes and peatbogs passes. Basins 5—7 lie in the marshes and peatbogs. Calcium-bicarbonate waters identified at the onset of observations became enriched in the sulphate ion with time (Fig. 3). Mineral contents which were rather stable throughout the observations corresponded to those recorded for basins 5, 6 and 7.

It appears that the difference in mineralization degree and nature between waters at sites 1—3 and 4—7 is due to the influence of bedrock and intense biogenic processes operating at sites 4—7.

Basin 8 lacated between debris-morainic ridges at the foot of Løvehovden and fed chiefly by snowmelt has a very low mineral content (Fig. 4, Tab. 1). Bicarbonate-calcium waters had a rather stable mineral content. Only after 19 July 1987 there was an increase in ion concentrations as a consequence of snow melting and thus, more intense action of water derived from the summer degradation of permafrost.

Concluding remarks

Calcium, bicarbonate and sulphate ions are the main ions contained in the waters subjected to analysis. As the summer passes, their concentrations increase at variable rates in various sites. Magnesium and sodium ions occur in smaller amounts. At all sites the chlorine ion is found in a small amount but its proportion remained unchanged throughout one-month observations.

Water basins 1 to 7 lying in close vicinity to one another have variable mineral contents and quantitative ion composition.

Basins 1—3 are occupied by bicarbonate-calcium waters with low mineral contents, whereas basins 4—7 are filled with highly mineralized calcium-sulphate-bicarbonate waters. The waters at sites 4—7 are richer in the magnesium ion, whereas those at sites 1—3 contain a larger amount of sodium.

The waters in basin 8 lying north of the main study area are bicarbonate-calcium waters with the lowest mineral contents.

Variations of mineral contents during the summer observations were largely due to the action of water derived from the summer degradation of permafrost. An intense increase in the mineral contents is mainly observed in shallow basins which depend to a larger extent on permafrost degradation than snow melting. These are basins 6 and 7, as well as basins 2 and 3 that disappeared during the observations. The depth of basin 1 and a continuous flow of snowmelt into basin 8 account for the stability of mineral contents of the waters.

The available results illustrate clearly the influence of various kinds of basin tributaries which include water derived from the melting of snow and permafrost degradation, depending on bedrock and the intensity of biogenic processes operating in the areas of basin occurrence.

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Streszczenie

Po północnej stronie przełomu Ebbaelva, u południowo-zachodniego podnóża Lovehovden, na podniesionych terasach morskich występują zbiorniki wodne i młaki (fig. 1). Tworzone one są z wód topniejącego śniegu oraz letniej degradacji wieloletniej zmarzliny. W okresie miesiąca, od 28 czerwca do 27 lipca 1987 roku, określono skład chemiczny opisanych zbiorników wodnych. Równolegle oznaczono skład chemiczny wód zbiornika usytuowanego między wałami gruzowo-morenowymi u podnóża Løvehovden. Zbiornik znajduje się na wysokości około 80 m npm, około 400 m na północ od podstawowego obszaru badań (fig. 4).

Analizowane zbiorniki wodne od 1 do 7, występujące na stosunkowo niewielkim obszarze charakteryzują się różnym stopniem mineralizacji i różnym ilościowo składem jonowym (tab. 1, fig. 2—3).

Wody zbiorników 1—3 to wody wodorowęglanowo-wapniowe, o niskim stopniu mineralizacji. Wody zbiorników 5—7 oraz stanowiska 4 to wody wapniowo-siarczanowo-wodoro-

-węglanowe, o wyraźnie większym zmineralizowaniu. Wody stanowisk 4—7 są bogatsze w jon magnezu, natomiast wody zbiorników 1—3 w jon sodu.

Wody zbiornika 8, położonego na północ od podstawowego obszaru badań, to wody wodorowęglanowo-wapniowe, o najniższej mineralizacji (tab. 1, fig. 4).

Zmienność mineralizacji w czasie letniej obserwacji to przede wszystkim wpływ wód powstałych w wyniku letniej degradacji wieloletniej zmarzliny. Intensywny wzrost mineralizacji obserwuje się przede wszystkim w zbiornikach płytszych, bardziej uzależnionych od degradacji zmarzliny niż tajania śniegu. Są to zbiorniki 6 i 7 oraz zanikające w czasie obserwacji zbiorniki 2 i 3.Głębokość zbiornika 1 oraz ciągły dopływ wód topniejącego śniegu w zbiorniku 8 jest przyczyną stabilności mineralizacji ich wód, w trakcie prowadzonych badań.

Przedstawione wyniki obrazują wyraźnie wpływ rodzaju wód zasilających zbiornik, zarówno wód topniejącego śniegu, wód powstałych w wyniku degradacji zmarzliny, uzależnionych od skał podłoża jak i intensywności procesów biogenicznych zachodzących na obszarach występowania zbiorników.