TRACE ELEMENTS IN DANISH TILLS

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Abstract. Samples of unweathered till from the last glaciation, taken from localities presumed to represent different ice movements (Norwegian ice, Baltic ice) has been analysed for traces of the following elements: Li, Cr, Mn, Co, Cu, Zn, Ni and Sr.

As a preliminary result the investigation shows that the contents of trace elements in Danish tills are very similar. In some localities with more than one till, a certain variation can be demonstrated. The question whether the trace-element content derives from the local pre-Quaternary deposits is mentioned.

The following are the preliminary results of an investigation of the contents of trace elements in Danish tills. The investigation was carried out as a collaboration between the Mineralogical Institute, the Technical University of Denmark and the Geological Survey of Denmark and was supported by a grant from the National Technical Sciences Fund (Statens teknisk-videnskabelige Fond).

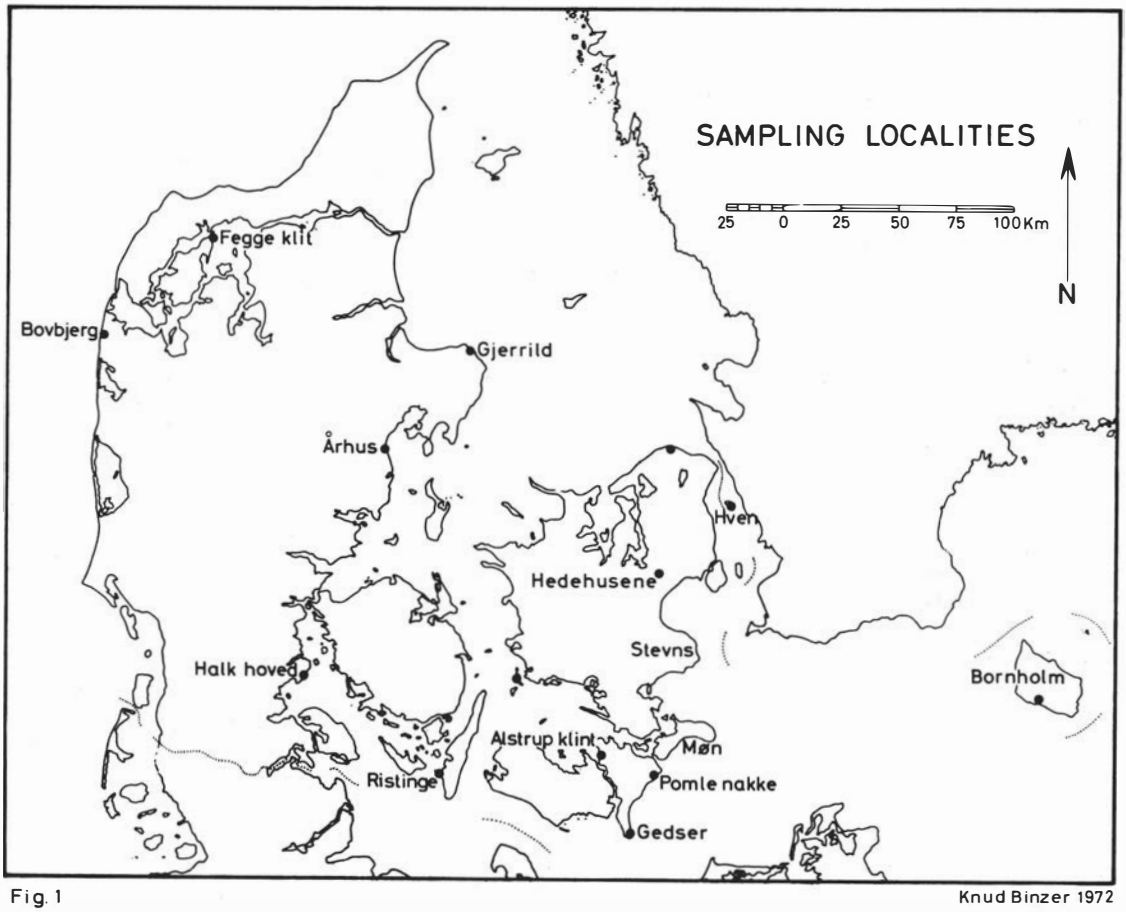

Fig. 1

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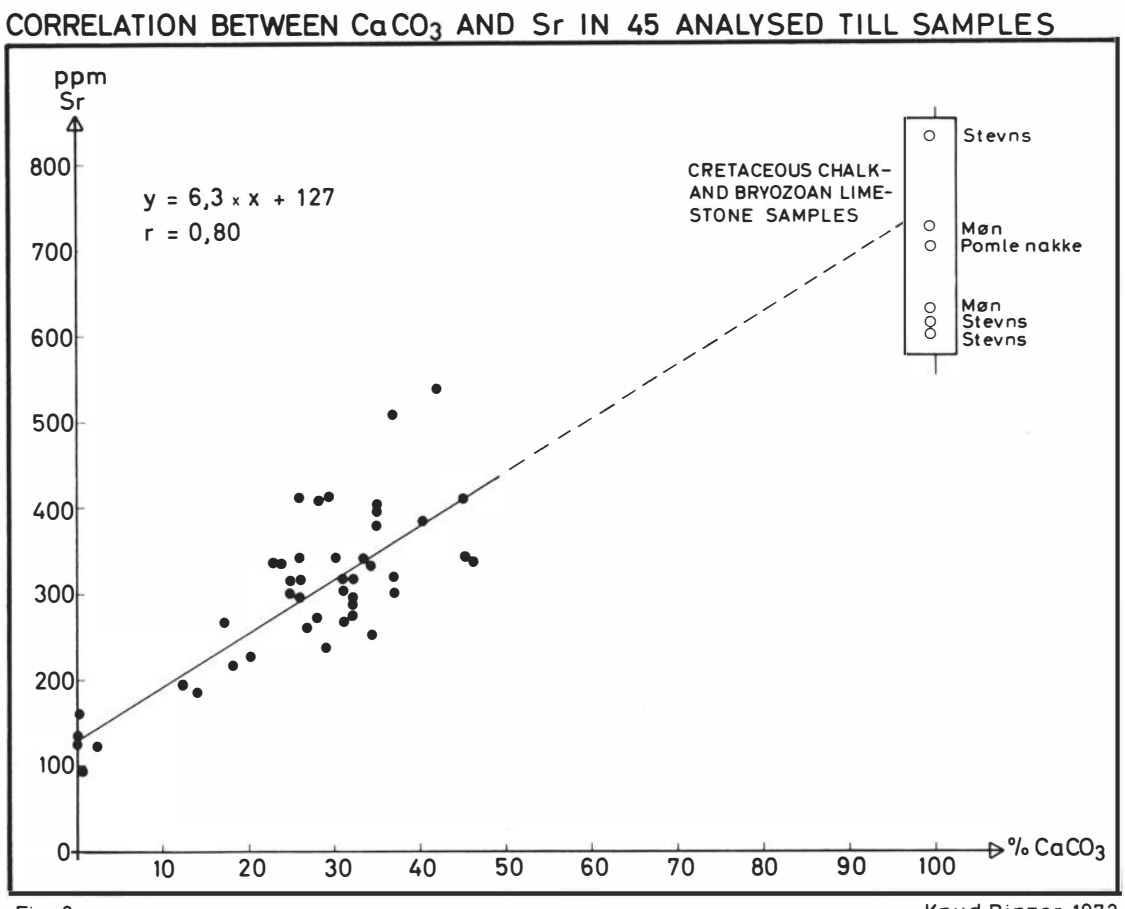

Fig. 2

The investigation included the measurement of the contents of heavy metals in tills which have not been affected by pedological processes. Apart from the geological aspect, the aim was to provide values for the trace-element contents, from which the heavy-metal contamination of soils could be evaluated.

The geological aspect of the investigation is whether there is a difference in trace-element content in tills which have been transported from different directions. If it is possible to demonstrate such a difference, this may contribute to the discussion about the ice movements in the Danish Quaternary sedimentary area.

The till material for the investigation consists predominantly of unaltered till from the Weichselian. The material represents what is generally believed to have been transported from the north (Norwegian ice) or from the southeast (Baltic ice). Most of the sampling localities (see map, Fig. 1) are situated on the coast, where the tills are exposed in cliffs (one locality on the Swedish island of Hven). One locality (Hedehusene) is situated in a gravel-pit, where a till more than 5 m thick covers the exploited meltwater deposits.

At each locality up to five samples, each of 5 kg, were taken. Each sample was divided into parts, and from a 1-kg subsample of the material the −32-micron fraction was separated. This fraction was chemically analysed. In this fraction a higher content of trace elements can be expected, and there is a possibility of securing a more representative sample of the till. A similar investigation of tills has been sucessfully carried out in Canada (R.W. May, 1970).

The analyses were performed at the Mineralogical Institute of the Technical University of Denmark with a Perkin-Elmer atomic-absorption spectrophotometer. The trace elements analysed for were Cr, Mn, Co, Ni, Cu, Zn, Sr and Li. Li was analysed to get a reference

Table 1. Average ($\bar{X}$) and standard deviation (s) of till analyses. The values are in p.p.m. of the ÷ 32-micron fraction, calculated on a $CaCO_3$-free basis (except Sr).

Locality	No.		Li	Cr	Mn	Co	Ni	Cu	Zn	Sr	% $CaCO_3$	% ÷32 μ
Hedehusene	1		27	72	564	<5	48	29	51	505	37	50
Alstrup	1		36	100	580	<5	36	43	133	299	37	50
Gedser	5	$\bar{X}$	37	85	541	6	35	36	100	263	30	65
		s	2	19	50	3	5	4	14	16	2	10
Pomlenakke I	5	$\bar{X}$	41	87	632	9	30	36	94	260	31	60
		s	4	8	48	4	6	5	16	35	2	8
Pomlenakke II	1		41	99	743	6	50	35	88	314	32	55
Hven I	3	$\bar{X}$	31	106	494	9	35	28	114	408	28	44
		s	4	12	41	5	3	4	8	2	1	1
Hven II	1		41	104	750	24	45	30	102	194	12	65
Gjerrild	3	$\bar{X}$	40	110	743	<5	40	48	88	358	42	38
		s	5	4	13		13	11	15	41	4	13
Feggeklit I	2	$\bar{X}$	37	77	491	22	42	59	132	133	0	33
		s	2	2	41	1	5	2	29	3	0	3
Feggeklit II	1		44	84	572	<5	37	51	109	300	25	45
Feggeklit III	1		58	101	789	13	39	46	113	342	30	60
Bovbjerg	5	$\bar{X}$	52	97	689	7	50	39	98	320	26	75
		s	7	7	54	4	6	4	14	16	1	0
Århus I	2	$\bar{X}$	37	93	661	9	60	40	141	107	2	35
		s	2	12	173	5	1	10	45	11	1	5
Århus II	1		48	106	1093	17	42	110	169	225	20	45
Ristinge	3	$\bar{X}$	30	127	713	10	39	32	151	402	40	52
		s	9	13	101	5	11	9	36	93	6	2
Halk Hoved I	3	$\bar{X}$	33	104	1826	20	61	38	134	370	35	70
		s	5	7	75	1	9	3	15	29	1	0
Halk Hoved II	3	$\bar{X}$	36	104	622	22	45	22	102	358	35	54
		s	5	4	75	4	4	1	7	32	4	4
Bornholm	3	$\bar{X}$	29	101	526	18	45	30	115	223	16	45
		s	2	4	37	1	4	4	7	34	2	0
Total	44	$\bar{X}$	38	98	716	10	43	36	108	301	27	54
		s	10	15	325	7	11	9	27	92	11	13
Earth crust after Krauskopf (1967)			20	100	950	25	75	55	70	375		
Analytical precision			2	10	64	4	16	4	44	80		

value for the analyses of forest soils being carried out by the botanists at the Institute of Ecological Botany, University of Copenhagen.

The values for the trace elements chosen are calculated on a $CaCO_3$-free basis, except for the Sr. This is done because the $CaCO_3$-content in the samples is very high and very variable. Furthermore, analyses of calcareous sediments in the Danish pre-Quaternary deposits, from which the $CaCO_3$ content in Danish tills is predominantly derived, shows that the calcareous sediments do not significantly contribute to any of the trace elements analysed for, except Sr. The variation of the Sr contents in the tills can be shown to be correlated with the $CaCO_3$ (see Fig. 2). The analyses of six Cretaceous calcareous sediment samples are shown as a control.

Table 1 shows that the trace-element distribution does not differ significantly in different parts of the country. However, there is a tendency to higher values for some of the elements (Li, Cr and Ni) in the northern part (Bovbjerg), compared with the southeastern part of the country (Pomlenakke).

Table 2 shows the values from two localities (Feggeklit and Halk Hoved) with more than one till. In Feggeklit there is a difference in the contents between the uppermost till (I) and the lowermost till (III). Li, Cr and Sr are higher in the lowermost till and Co, Ni, Cu and Zn are higher in the uppermost till. The till (II) in

Table 2 The values in ppm

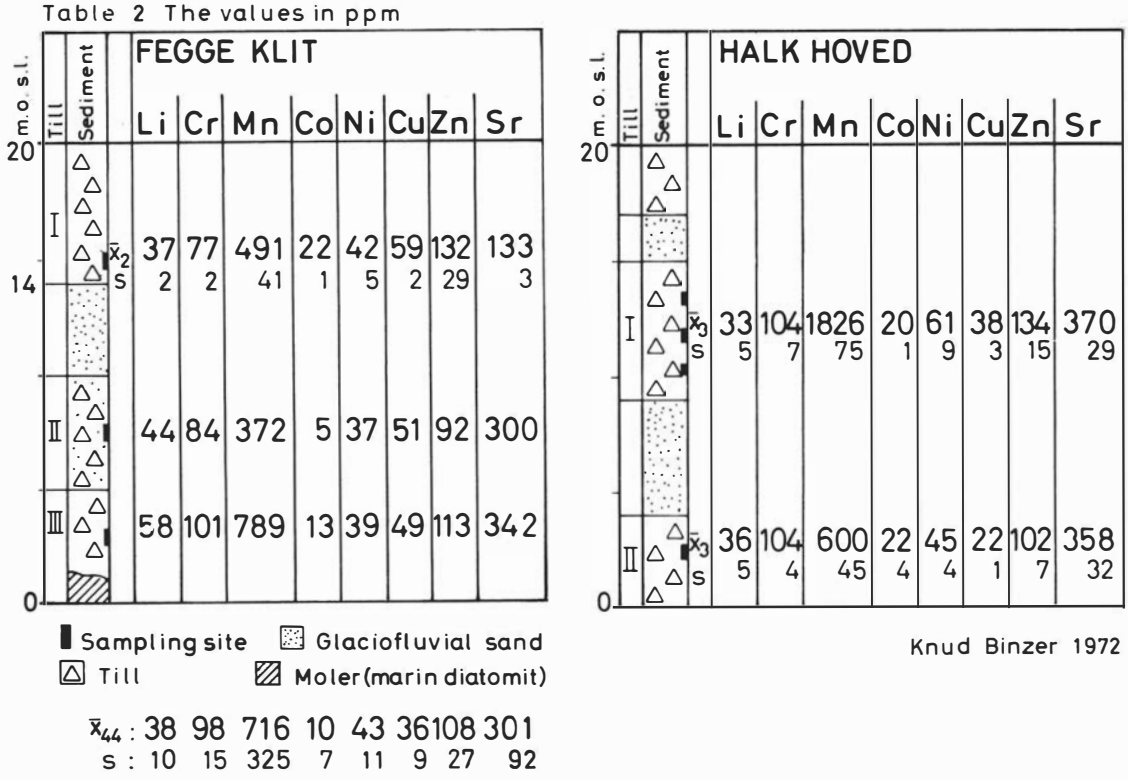

Table 3. Analyses of Quaternary clays and Danish pre-Quaternary sediments (values in p.p.m.).

Sediment		Li	Cr	Mn	Co	Ni	Cu	Zn	Sr
"Stoneless clay" Møn		28	53	458	10	29	20	157	128
Cyprina clay Ristinge		33	90	548	12	34	23	61	109
Stoneless clay Ristinge		35	114	447	18	48	26	94	147
Søvind marl Eocene, Århus		64	93	377	39	116	50	198	756
Bryozoan limestone Danian, Stevns		2	<5	215	<5	8	7	88	599
Fish clay Danian, Stevns		609	310	40	100	1200	117	910	1682
Chalk Senoian, Stevns		2	<5	95	<5	<5	7	26	615
Chalk Senonian, Møn		1	<5	261	<5	<5	6	16	628
Jurassic clay Bornholm		77	114	98	20	37	15	69	97
Jurassic sand Bornholm		4	41	41	5	10	<5	26	37
Average of 44 till samples	$\bar{X}$	38	98	716	10	43	36	108	301
	s	10	15	325	7	11	9	27	92

between seems to occupy an intermediate position. In Halk Hoved the contents of Mn and Ni in the upper till (I) are significantly higher than in lower till (II) and also higher than the total average of the samples analysed, and the content of Cu is also higher. Here, consequently, is a till which it is possible to recognise and distinguish from other tills.

To elucidate the question about the sources of the trace elements in the tills, Table 3 shows analyses of some Quaternary clays and some Danish pre-Quaternary sediments. The table shows that the Quaternary clays generally have lower contents of the trace elements than the total average of the till material. The Tertiary "Søvind marl" shows higher values, except for Cr. The Cretaceous calcareous sediments have very low heavy-metal contents, and only the Sr content is high. The Cretaceous clay "Fish clay", on the contrary, shows remarkably high values of the trace elements, but this clay outcrops with such a small thickness and with so small a regional distribution that it is questionable whether it has contributed to the trace-element content in the tills. The Jurassic clays have higher contents of Li, Cr and Co compared with the till average, and the Jurassic sand shows lower values, as expected. The table shows that the Danish pre-Quaternary deposits include sediments with high trace-element contents, from which the contents in the Danish till may have been derived.

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