Sub-Fossil Hekla Pumice from Denmark.

By

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Abstract.

Sub-fossil pumice of intermediate composition has been found in three places in North Jutland. Petrographically and chemically it can be stated as probable that these pumices belong to the same drift as similar pumice finds in Western Norway, Fiskarhalvøen, Novaya Zemlja, Spitzbergen and Greenland. Evidence is offered that they originate from the Hekla volcano in Iceland. In Denmark the pumice is covered with peat from the sub-boreal period, in Western Norway it is found on the uppermost *Tapes*-line for which reason the time of eruption can be fixed to about 2000 B. C. which again proves that Hekla already some 4000 years ago produced material of a composition and nature quite comparable to its present products. The significance of the possibility of establishing a synchronous level in several circum-Atlantic countries by means of the Hekla pumice is discussed.

Far back in time pumice and slags washed ashore on the beaches of the Scandinavian countries have been known but only casually mentioned in geographical descriptions and travel records, a fact which renders it difficult to obtain information on the subject. One of the oldest — perhaps the oldest — description has been given by HANS STRØM, a clergyman from West Norway (STRØM, 1762, p. 58)[1].

In the second volume of his "Reise nach dem hohen Norden" (p. 99) VARGAS BEDEMAR mentions the occurrence of large quantities of rounded, black pumice at Jupvik, Finmarken (BEDEMAR, 1819). In another book from the same period he describes a pumice from Iceland as "quite conformable to balls of the same substance which I found at Jupvig in Norway (70°10' North) deposited on top of one another at a height of some feet. They may have been washed ashore at high tide by a current coming from Iceland. Our illustrious Admiral LØWENØRN[2]) observed such balls floating on the water after a small volcanic island near Iceland had been sighted". (BEDEMAR, 1817, p. 5).

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[1]) He states that "Pimpsteen (Pumex pyritæ cinereus Linnæi) findes undertiden ved vore Strandbredde, men skielden", and he uses a full page on a more detailed account of what he has seen or heard.

[2]) ADMIRAL POUL LØWENØRN, b. 1751, d. 1826. In 1786 he visited Iceland and East Greenland waters. The pumice observed presumably came from eruptions in Eldeyar.

A really comprehensive study of these pumices and slags was undertaken by H. BÄCKSTRÖM, whose work contains ample references to literature on earlier observations (BÄCKSTRÖM, 1890).

BÄCKSTRÖM was able to distinguish at least four types of this porous rock material, which was at his disposal from almost all open coasts in Norway. They were:

1. Gehlenite-spinel-slags (p. 16).
2. Light liparitic pumice (p. 25).
3. Acidic, glassy andesitic pumice (p. 27). He subdivided this group into a brownish and a blackish type.
4. Basic, olivine-carrying, augite-andesite pumice (p. 37).

The slags are an artificial product and will not be dealt with here. BÄCKSTRÖM records genuine volcanic pumice from the following localities: The whole west coast of Norway, particularly in the north, the Arctic Sea coast as far as Fiskarhalvøen and Novaya Zemlja, Spitzbergen, an isolated occurrence at Eqalunguit near Godthaab in West Greenland, and another isolated occurrence at Strömstad in Bohuslen, Sweden. BÄCKSTRÖM assumes that Groups 2 and 4, but not Group 3, came from Iceland.

The light, liparitic pumices are fairly rare while, on the other hand, the andesitic and basic pumices both have a fairly wide regional distribution and are rather frequent locally. As the pumices to-day chiefly occur at levels now well above ordinary water level, they have been used in northern Scandinavia by the Quarternary geologists who by means of the pumice horizons have been able to follow a certain waterlevel mark over a long distance. In this connection I can refer to I. UNDÅS's recent investigations in North and West Norway, which contain references to literature dealing with this matter (UNDÅS, 1938, 1945), and K. FÆGRI's works from more southerly localities (FÆGRI, 1943).

So far literature has no records of finds of pumice from Denmark, whereas slags are common along the west coast of Jutland[1]).

However, in 1948 the Mineralogical Museum in Copenhagen received from Mr. FRODE VESTERGAARD, a schoolmaster of Heden, Vendsyssel, reports of a miscellaneous find from this neighbourhood, which also contained a piece of volcanic pumice. Farmer KARL JENSEN of Sovkrog, who found the material, kindly let me have it for examination. Later a second piece from the same locality was given to me. Looking through the collections of the Mineralogical Museum, a third piece of pumice (Mus. No. 93, 1910) from Bejstrup, Hanherred, was encountered, and the collection of the Geological Survey of Denmark held five pieces from a stony plain near Kandestederne, Vendsyssel.

From an examination under the microscope of the pumice from all three places I found that they were in striking mutual agreement and that

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[1]) At the twelfth Scandinavian Naturalists' Congress held in Stockholm in 1880 J. S. DEICHMANN BRANTH read a paper on "Geological conditions in the northernmost part of Jutland" and briefly mentioned the occurrence of pumice in Denmark (DEICHMANN BRANTH, 1880, p. 277). To judge from the localities the finds were presumably slags (cf. below); the material seems to have been lost.

they all could be referred to BÄCKSTRÖM's third group, a conclusion already arrived at by N. V. USSING for the piece from Bejstrup[1]).

In order to obtain a basis of comparison with the material from Norway I approached Mr. I. UNDÅS, who kindly let me have two different samples of Norwegian pumice, a brown type from the *Tapes*-line about 12 metres above sea level from Blomøy near Bergen, and one from a lower level of the *Trivia*-line 5.7 metres above the sea from the same locality (UNDÅS, 1945, p. 446). I also approached Professor FÆGRI, who gave me a sample from Djupadal, Bømlo, from the 11 meter level (FÆGRI, 1943, p. 52). The brown pumice from the highest level at Blomøy proved to be identical with the sample from Bømlo as well as with the Danish pumice, of which the Sovkrog samples were found 10–11 metres above sea level (cf. p. 46), and the samples from Kandestederne 25–30 feet above the sea.

While working up the material I was struck by its obvious likeness to an andesitic pumice previously described by me from Julianehaab, South Greenland (NOE-NYGAARD, 1944), the like of which had later been found in one more place near Holsteinsborg in West Greenland. This naturally led to a renewed examination of the Greenland material together with the rest.

BÄCKSTRÖM does not give more detailed data of the andesitic pumices which he examined under the microscope but confines himself to a classification based on their immediate macro- and microscopical appearance and on single chemical tests. Chemically there seems to exist no great difference between his two subgroups, the black and the brown type.

My earlier determination of the refringence of the glass in the pumice from Julianehaab at 1.522 ± 2 and a later determination of the pumice from Holsteinsborg at 1.524 ± 2 have been repeated so that all determinations given below have been carried out with the same set of refringence liquids afterwards verified on a refractometer. Control determinations were carried out by Mr. H. PAULY, M. Sc. Table 1 shows the result of the optical determinations.

Table 1.

	Denmark			Norway		Greenland	
	Sovkrog	Kande-stederne	Bejstrup	Blomøy	Bömlo	Julianehåb	Holsteins-borg
Refringence of glass	1.525 ± 1	1.524 ± 1	1.525 ± 1	1.525 ± 1	1.524 ± 1	1.525 ± 1	1.525 ± 1
Porphyritic plagioclase .	48% an		45% an	48%, 43%		48%, 45%	
Groundmass: Plagioclase .	×		×	×		×	×
Clinopyroxene	×		×	×		×	×
Ore	×		×	×		×	×

[1]) Handwritten note on the label of the sample.

As will be seen, there is exceedingly good agreement between the pumice from the various localities.

In order to see whether the agreement was proof against a chemical test I had Miss ME MOURITZEN, Civil Engineer, analyze three of the samples, viz., one from Sovkrog, Vendsyssel, another from the *Tapes*-line at Blomøy Norway, and a third from Julianehaab, West Greenland. The result of the analyses may be seen in Table 2, which also shows an analysis from Shoal Point, Spitzbergen, published by BÄCKSTRÖM (p. 29), and a partial determination including SiO_2 and alkalis of a sample from Fiskarhalvøen.

Table 2.

	1	2	3	4	5
SiO_2	63.16	62.33	63.53	64.39	64.42
TiO_2	0.87	0.97	1.05	0.54	
Al_2O_3	13.84	14.25	13.72	13.96	
Fe_2O_3	1.10	0.95	1.36	6.94 [1]	
FeO	5.04	5.16	5.03		
MnO	0.15	0.17	0.18		
MgO	1.06	1.06	1.22	1.34	
CaO	4.03	4.04	3.90	3.58	
Na_2O	5.58	5.61	5.39	5.16	4.54
K_2O	2.40	2.40	2.35	2.88	2.75
P_2O_5	0.39	0.33	0.37	—	
H_2O^+	1.17	1.28	0.79	—	
H_2O^-	0.61	0.91	0.27	—	
Org. subst.	0.17	0.15	0.43	—	
Sum	99.57	99.61	99.59	98.79	—

[1]) Stated as Fe_3O_4.

1. Pumice (brownish), Sovkrog, North Jutland. ME MOURITZEN anal.
2. „ „ Blomøy *Tapes*-line, West Norway. ME MOURITZEN anal.
3. „ „ Julianehaab. S.W. Greenland ME MOURITZEN anal.
4. Pumice (black variety), Shoal Point, Nordostlandet, Spitzbergen. Quoted from H. BÄCKSTRÖM.
5. Pumice (brown variety), Fiskarhalvøen. Ibidem.

According to this the agreement is also chemically almost perfect, and we are justified in saying that petrographically as well as chemically the rocks from these widely different localities are practically identical. In other words, *the pumices examined must belong to the same volcanic focus and, to all appearances, even to the same eruption*, a fact which BÄCKSTRÖM (BÄCKSTRÖM, 1890, p. 29) already considered likely of the then known occurrences of pumice belonging to his third group.

In Table 3 are given Eq-Mol-% and Eq-Norm for the three new analyses.

The next question that comes up is: where is the volcano which produced the pumice material?

Table 3.

	1	2	3		1	2	3
Si	60.1	59.4	60.2	Q	12.0	10.4	13.6
Ti	0.6	0.7	0.7	Or	15.0	15.0	14.0
Al	15.4	15.9	15.3	Ab	51.5	51.5	49.5
Fe···	0.8	0.7	1.0	An	5.2	6.5	6.5
Fe··	4.0	4.2	4.0	Σsal	83.7	83.4	83.6
Mg	1.5	1.5	1.8	Ap	1.2	0.8	1.2
Ca	4.0	4.1	4.0	Il	1.2	1.4	1.4
Na	10.3	10.3	9.9	Mt	1.6	1.4	2.0
K	3.0	3.0	2.8	Wo	4.1	4.1	3.6
P	0.3	0.2	0.3	Fs	5.2	5.6	4.6
(H_2O)	(5.6)	(7.0)	(5.8)	En	3.0	3.0	3.6
	100.0	100.0	100.0	Σfem	16.3	16.6	16.4

Same numbers as in table 2.

To judge from the distribution—North Jutland, the whole West coast of Norway, Fiskarhalvøen, Novaya Zemlja, Spitzbergen, and West Greenland—the Gulf Stream must have been the principal factor of distribution. Consequently, at least the following geographically possible localities must beforehand be taken into consideration when trying to determine the position of the volcano:

The Canary Islands,
The Cape Verde Islands,
The Azores,
The Antilles and
Iceland (with a south-moving wind).[1]).

The volcanic material of the first two island groups is too alkaline to allow them to be accepted as a possible place of origin of the pumice in question.

As for the Azores and the Antilles, neither can, however, at once be rejected as possible sources. On the diagram Fig. 1 I have entered the series of chemical analyses of rocks from the Azores found in the F. v. WOLFF tables (v. WOLFF, 1931). From WASHINGTON's collection of analyses (WASHINGTON, 1917) from the Antilles have been selected all analyses of volcanic rocks from the central, large island, Guadeloupe, as a paradigm of this province. MgO, the significant constituent of the more refractory minerals is at one corner, while FeO, the significant constituent of the medium refractory minerals is at another corner, and total alkalis, the significant constituent of the less refractory minerals is at the third corner. L. R. WAGER and W. A. DEER have previously used this procedure (WAGER and DEER, 1939). The andesitic pumice is indicated by a

[1] BÄCKSTRÖM also mentions Jan Mayen as a possible source, but according to the new finds from a region as far south as Denmark I cannot agree with him on this point (BÄCKSTRÖM, 1890, p. 32).

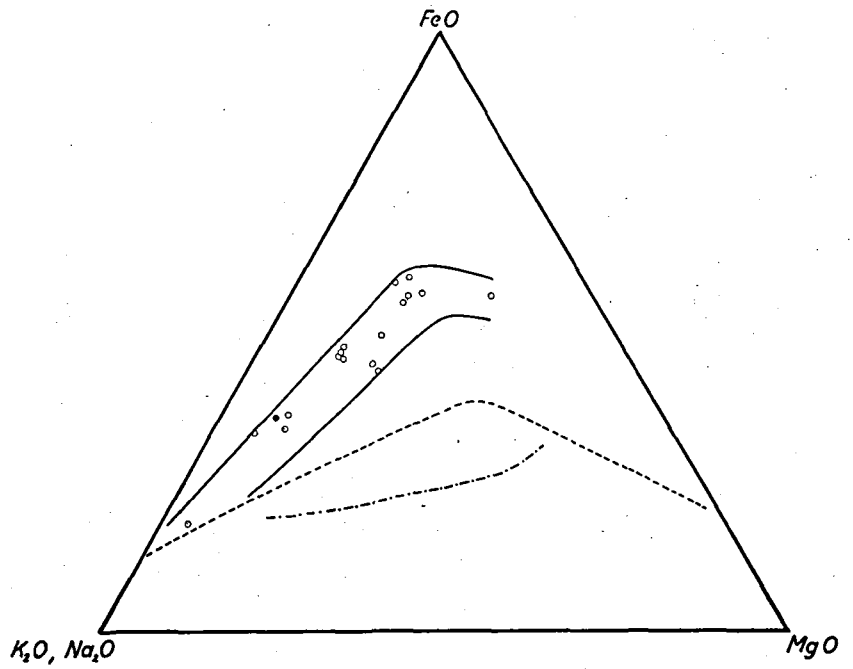

Fig. 1.

Triangular diagram (comp. text). Lower curve shows the trend of variation of the volcanic rocks from the Azores, and the intermediate curve, that of the Antilles. The andesitic pumice from Sovkrog, Jutland is shown by a filled-out circle which falls within a belt comprising 17 analyses of Hekla rocks (open circles between full-drawn lines).

filled-out circle in the diagram, and it will at once be seen that it does not agree with any of the two volcanite groups (only the main trend is shown, but the scattering is negligible at the intermediate to acid end of the diagram).

Iceland is still to be considered. Naturally, BÄCKSTRÖM also considers this possibility but rejects it as follows: "Recente oder quarternäre Gesteine mit ähnlicher Zusammensetzung sind indessen bis jetzt nicht aus Island beschrieben oder analysiert" (BÄCKSTRÖM, 1890, p. 34). However, BÄCKSTRÖM's publication is now 60 years old, and investigations from the last ten years have proved that intermediate to acid rocks are represented to a considerable extent in the volcanic focus of the Hekla area (cf. THORARINSSON, 1944, p. 81). Also, after the latest Hekla eruption in 1947–48 a large number of new analyses have been carried out, some of which have been published by T. EINARSSON (EINARSSON, 1950, p. 34), whereas others have not yet appeared in print.

On the diagram, Fig. 1, I have entered the position of 17 superior analyses from Hekla. The position of the andesitic pumice fits well into the zone occupied of the Hekla rocks.

Chemically Hekla is rather exceptional in Iceland, so *I consider it to be beyond all doubt that our andesite came from a prehistoric volcanic eruption of Hekla or its immediate neighbourhood in Iceland.* Consequently, the hypothesis—submitted with all due reservations by BÄCKSTRÖM—that the pumice should have come from the Pacific Ocean via the Arctic Sea, should now be given up (BÄCKSTRÖM, 1890, p. 36). Table 4 shows a series of analyses of intermediate to acid pumices or ashes originating from various eruptions in Hekla. That the pumice from Denmark (no. 4 in table 4) now under discussion is chemically closely related to these is beyond doubt. Apart from silica and alumina the values for MgO and CaO should be specially noticed as well as the values for Na_2O and K_2O.

Table 4.

	1	2	3	4	5	6	7	8	
SiO_2	68.05	65.70	63.13	63.16	62.22	61.88	60.50	57.71	SiO_2
TiO_2	0.42	0.80	0.88	0.87	1.09	1.03	0.60	0.72	TiO_2
Al_2O_3	14.21	14.88	13.84	13.84	15.69	16.11	15.32	16.36	Al_2O_3
Fe_2O_3	5.02	1.73	5.29	1.10	3.32	2.11	2.74	3.69	Fe_2O_3
FeO	1.63	3.77	5.88	5.04	6.71	6.47	6.20	6.45	FeO
MnO	0.15	0.10	0.08	0.15	0.12	0.26	0.21	0.21	MnO
MgO	0.37	0.73	1.22	1.06	1.30	1.76	1.68	2.57	MgO
CaO	3.07	3.34	4.55	4.03	4.95	4.93	5.22	6.06	CaO
Na_2O	5.23	4.72		5.58		4.21	3.62	4.26	Na_2O
K_2O	1.77	2.12		2.40		1.16	1.93	1.11	K_2O
P_2O_5	0.09	0.12		0.39		0.14	0.50	0.53	P_2O_5
H_2O+	0	1.94		1.17		0.34	1.74	0.38	H_2O-
H_2O-	0	0.24		0.61		0.06	0.81	0.02	H_2O+
Org. subst.	0	—		0.17		—	—	—	Org. subst.
Sum	100.01	100.19		99.57		100.76[1]	101.07	100.07[2]	

1. »Liparitic« xenolith, Hekla, April 1947. N.-N. ME MOURITZEN anal.
2. Pumaceous ash, Hekla. Layer VI Áslákstunga fremri. S. THORARINSSON leg. NAIMA SAHLBOM anal.
3. Pumice. N.-N. No. 7. Hekla, April 1947. ME MOURITZEN anal.
4. Pumice, Sovkrog, North Jutland. ME MOURITZEN anal.
5. Pumice. N.-N. No. 14. Hekla, April 1947. ME MOURITZEN anal.
6. Pumice fallen at Árkvörn (light type). Hekla, beginning of eruption 1947. JÓH. JAKOBSSON anal.
7. Coarse ash. Hekla, Layer XI Skallakót. S. THORARINSSON leg. NAIMA SAHLBOM anal.
8. Pumice fallen at Árkvørn (darker type). Hekla 1947. JOH. JAKOBSSON anal.

(Nos. 1, 3, and 5 unpublished analyses from the author's material, Nos. 2 and 7 cited from THORARINSSON (1944. p. 81), Nos. 6 and 8 from T. EINARSSON, 1950 p. 34).

The next question is: When did the eruption take place? For an answer we must return to the circumstances of the finds in the various localities.

Denmark, Sovkrog in Vendsyssel: The pumice from here was found together with rolled pieces of wood and branches, lignite, hazelnuts, small pieces of yellow and light brown amber and a single piece of

[1]) Sum stated by T. EINARSSON as 99.76.
[2]) — — — as 99.97.

dopplerite—light materials typically washed ashore. The finder, Mr. KARL JENSEN, Mr. FRODE VESTERGAARD, and I visited the place in April 1950.

The locality is about 5 kilometres W–NW of Aalbæk immediately north of Gaardbo Sø in Vendsyssel and about 150 metres due south of Sovkrog Farm. The latter is situated in the angle formed by the road to Raabjerg Church and the road to the village of Tuen. A gently sloping field already under culture lies to the south of the last named road, and due south of this again a new field has recently been laid out, during which work the material mentioned was revealed.

Before the cultivation work the area held a small peat bog of about 100 square metres. Its thickness was only about $^1/_2$ meter, and it was found to rest on sand. The peat was dug out, the hole filled with sand, and the peat soil was afterwards spread on top to improve the soil. The pumice and the other material accompanying it were found under the peat bog on sand covered by the peat. The height above sea level of the layer in question is 10–11 metres. The whole area has a gentle slope towards Gaardbo Sø and no signs of wave-cut terraces or old shore lines are seen.

After the turning upside-down of the field, things of the above-mentioned kind were found on the surface during later work in the field. The owner had collected part of this material, too, and let me have a look at it.

Several hundred pieces of amber had been collected in all—some of them as big as a match box or a hen's egg—also another two pieces of dopplerite and one more piece of pumice identical with the first one.

Immediately west of the new field, another quite similar small peat area was still undisturbed. Through this I made a ditch down to the sand underneath. On the surface of the sand and in the lowermost inches of the peat I met with some pieces of branches and rolled wood, and Mr. KARL JENSEN, who accompanied me, could tell us that this layer was identical with the one which contained the pumice in his own field. I took a couple of samples of the peat, one from the lower and one from the upper part. Dr. JOHS. IVERSEN, of the Geological Survey of Denmark, kindly undertook a preliminary examination with the result that the *peat can be said to belong to the sub-boreal period*, and, further, that the upper sample contains marine diatoms. A more thorough investigations has not yet been made.

Kandestederne, Vendsyssel: Five pieces of pumice were kept in the collections of the Geological Survey of Denmark. They had been collected by K. J. V. STEENSTRUP in 1894 on a gravel plain at between 25 and 30 feet above sea level at Kandestederne in Western Vendsyssel, in other words, perhaps a little lower than the Sovkrog specimens, although the statement of height is only approximate.

Bejstrup, Eastern Hanherred: A single piece of pumice was found here in 1910. It had been sent to the National Museum together with a passage-grave find. From here it had come to the Mineralogical Museum. The piece bears marks on it caused by man, but it is not stated that it belongs to the archeologically dated find itself.

Western and Northern Norway: I. UNDÅS allows for three pumice drifts in Norway since the Glacial Age and uses the two stratigraphically.

One indicates the position of sea level at the close of the *Tapes*-period and carries brownish pumice of the andesitic type described in the present paper. At Blomøy near Bergen this line is about 12 metres above the present sea level[1]).

The pumice from Djupadal, 11 metres above the sea (FÆGRI, 1943, p. 52) corresponds perfectly to the pumice from the upper stratum described by UNDÅS. This layer is dated through pollen-analyses by FÆGRI.

Spitzbergen: BÄCKSTRÖM with A. E. NORDENSKJÖLD as a source states that the andesitic pumice from Shoal Point was found only at 0–2 metres above sea level.

Greenland: So far exact information of the position of the finding places compared with the present sea level is not available, but as the piece from Holsteinsborg was found together with an artificial slag, it can hardly have been collected far from the present sea level, neither can the Julianehaab piece which was found on the beach[2]).

Bohuslen, Sweden: The piece of pumice found near Strömstad in Bohuslen is only the size of a bean, 8 by 16 by 18 millimetres, and according to BÄCKSTRÖM of a yellow-brown colour. He classified the piece as an andesite but adds: "ob es sich aber den andesitischen Bimssteinen des nördlichen Norwegens und Spitzbergens anschliesst, lässt sich nicht bestimmt entscheiden, da einerseits die geringe Quantität eine chemische Untersuchung nicht erlaubte, anderseits das mikroskopische Aussehen keine auffallende Ähnlichkeiten erwies". The piece comes from a post-Glacial bank of shells 22.2 metres above the sea.

Literature contains several pieces of information on finds of pumice along the Swedish Kattegat coast. Some of these can be dated archeologically, (BAGGE, 1934, FRÖDIN, 1906, FRÖDIN, 1911, JANSSON, 1936, LIDÉN, 1940, SARAUW and ALIN, 1923).

A petrographical description of this pumice material is not yet available, but it is to be hoped that otherwise dated pumice finds will be taken care of by geologists in the future.

When the time of the eruption which produced the pumice is to be determined, the small piece from Strömstad, Bohuslen, must be left out of consideration as its colour does not agree with that of the others, and BÄCKSTRÖM also doubts that it belongs to the same pumice drift. Spitzbergen and Greenland must also be left out for the time being, as information from these areas is still too incomplete.

Left, then, is to-day the evidence from Norway and Denmark. In Norway

[1]) The other, lower level carries black pumice of a different type, for which reason this stratum cannot possibly have been produced by weathering of the one above.

[2]) Although more detailed investigations on this point are still to be carried out, it may already now be assumed that the *Tapes*-line is not far from the present coast-line—in Greenland because the ice cap here never disappeared and consequently did not bring about a large-scale release movement of the country — at Spitzbergen because it was a question of a relatively small landmass only. We find the latter circumstance again in Iceland, where the *Purpura lapillus*-transgression only reaches heights of 4–6 metres above the present coast-line. (THORARINSSON, 1951). Should later finds of pumice in Greenland confirm this, the marine deposits indicating a warmer period, recently dealt with by D. LAURSEN must be late-Glacial, not post-Glacial (LAURSEN, 1949).

the andesitic pumice is found in deposits from the end of the Tapes-period. In Vendsyssel the pumice stratum was covered with sub-boreal peat, and the pumice from Kandestederne was found on a gravel plain at an almost corresponding level.

These observations so far support each other by *placing the the volcanic eruption to the transition between the atlantic and sub-boreal periods, in other words about 4000 years back in time.*

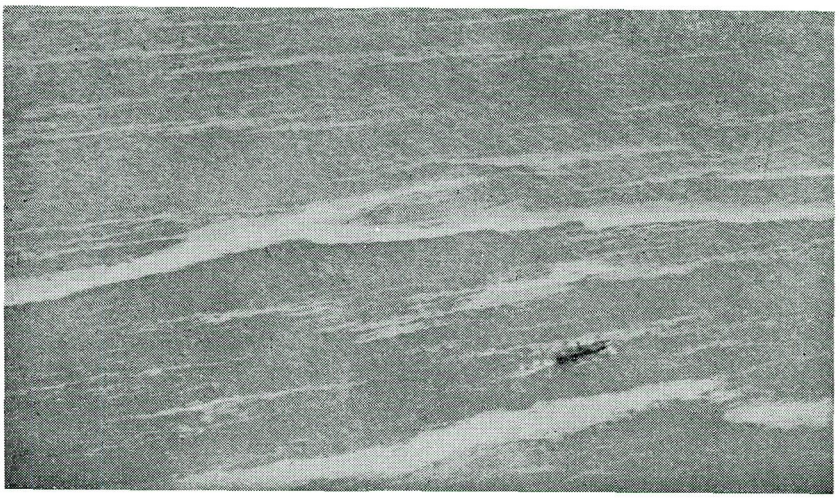

Fig. 2.

Pumice drift in the open sea from the Hekla eruption in 1947 as seen from an airplane off the Vestmanna Islands a few days after beginning of eruption. The steamer in lower, right corner gives an idea of the size. NOE-NYGAARD, phot.

It is obvious that a common level marking a definite point of time in Norway and Denmark would be of great importance to Quaternary geology, as it will make possible a certain parallelization of synchronous formations in both places, in which connection it should be emphasized that JOHS. IVERSEN at Dybvad in Eastern Vendsyssel has been able to establish that here the third transgression phase of the four found at Søby is the highest (IVERSEN, 1937, 1943). The perspective indicated above will be no less interesting if future investigations will provide us with fully reliable data for the height above the sea of the Greenland and Spitzbergen pumice from the same source, and perhaps also prove that the same pumice drift has left its traces in the British Isles.

Circumstance has to a certain extent forced countries separated by the ocean to have each their own chronology; it seems as if isolated Iceland might be of assistance to her overseas neighbours in the study of the chronology of the post-Glacial Age.

The andesitic pumice has still another perspective. A brief account of its petrography and chemical composition has been given on p. 41—42, and

such good agreement was found from place to place that the pieces were considered as belonging to the same pumice drift. An examination of the various possibilities of a determination of their place of origin pointed clearly to the Hekla area in Iceland. The old Hekla lavas have recently been investigated by G. KJARTANSSON and myself, and it seems certain to me that the eruption history of Hekla falls into two main parts, viz. an older more effusive with basaltic lavas, and a younger with explosive initial outbursts of rather acidic composition and "andesito-basaltic" lavas. Since we now have evidence that the Hekla field already about 4000 years ago gave off products of almost the same type as to-day, we are able to say that the older history of Hekla must be older than that. In other words, that type of volcanic activity in Hekla which has been known from the time of the first settlers had been in action for at least some 3000 years before that.

After this had been written I have been in contact with SIGURDUR THORARINSSON, who has now a paper in the press in which he draws a parallel between UNDÅS's upper pumice layer and the *Purpura lapillus*-transgression in Iceland (BARÐARSON, 1908). THORARINSSON is also inclined to place the time of eruption for the brown pumice, described in the present paper, at about 2000 B.C., that is, not long after deposition of stratum H_4 in his Iceland tephra-diagram. Independent of me he believes the brown pumice of west Norway to have come from the Hekla region in Iceland.

And here we are again at the point at which we started: An Icelandic volcano has delivered a material which makes it possible to correlate synchronous strata in Denmark and Norway; in these places we have been able to date the material in not too bad a way and thereby to help with the absolute dating of a single stratum in THORARINSSON's magnificent but still for the main part relative tephra-diagram of Iceland.

The reason for publishing this paper now on so scanty a material is my hope that it might call attention to the problem with which it deals and perhaps thus stimulate further observations in the field, so that exact age determinations — by pollen analyses or archaeological finds — can be secured. The great similarity of the material from one Hekla eruption to another also makes further detailed studies highly desirable.

Miss *Me Mouritzen* has kindly made the new chemical analyses and Mr. *H. Pauly* the control measurements of refringence of the volcanic glass; I have had fruitful discussions with Mr. *Troels-Smith* and *Dr. Johs. Iversen* on the subject, my best thanks to all of them.

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Dansk resumé.

Ved Sovkrog lige nord for Gaardbo sø og ved Kandestederne ved Vendsyssels vestkyst samt ved Bejstrup i Øster Hanherred er der fundet subfossile, brune pimpsten af intermediær sammensætning. En sammenligning med pimpsten fra Blomøy og Bømlo i Vestnorge viser, at pimpstenen fra Nordjylland tilhører samme pimpstensdrift som disse; ganske lignende pimpsten er fundet på Fiskerhalvøen, Novaya Zemlja, Spitzbergen og Grønland. En petrografisk og kemisk undersøgelse godtgør, at pimpstenen stammer fra et vulkanudbrud i Hekla på Island! Fundomstændighederne i Norge, hvor pimpstenen på Bømlo og Blomøy ligger på højeste *Tapes*-niveau og ved Sovkrog i Danmark, hvor den dækkes af subboreal tørv, viser, at udbruddet må have fundet sted omtrent på overgangen mellem atlantisk og subboreal tid eller ca. 4000 år tilbage i tiden.

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