

MEDDELELSER OM GRØNLAND

UDGIVNE AF

KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND

Bd. 105 · Nr. 3.

THE SCORESBY SOUND COMMITTEE'S 2ND EAST GREENLAND
EXPEDITION IN 1932 TO KING CHRISTIAN IX.'S LAND

LEADER: EJNAR MIKKELSEN

GEOLOGICAL INVESTIGATIONS IN EAST GREENLAND

PART II: GEOLOGY OF KAP DALTON

BY

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WITH 3 FIGURES IN THE TEXT AND 7 PLATES

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1935

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I. INTRODUCTION

In Greenland Tertiary sediments have been found in three widely separated areas where their preservation is due to close association with Tertiary basalts. On Disko Island and the peninsulas of Nugsuak and Svartenhuk, plant-bearing sediments of Upper Cretaceous or Lower Tertiary age are found resting conformably on beds containing marine Senonian fossils. In East Greenland plant-bearing sediments, found originally by Koldewy's Arctic Expedition of 1869—70, occur on Sabine Island. O. Heer who first described these plant remains considered them to be of Tertiary age and F. J. Mathiesen, after a further examination of material from the same locality collected by N. Hartz, J. M. Wordie and R. Bøgvad, states that "all available facts point to an early Tertiary age for these deposits" (13, p. 61). The third locality for Tertiary sediments, that at Kap Dalton in East Greenland, was discovered by O. Nordenskjöld during the Amdrup-Hartz Expedition. Here well-preserved marine fossils and plant remains occur together. The geological results of a second visit to this locality are presented in the present paper.

Nordenskjöld's original description of the geology of Kap Dalton is brief (5), but the marine fossils collected by Hartz were described in detail by J. P. J. Ravn (4). The fauna came from two horizons called, after characteristic fossils, the *Cyrena* Beds and the *Coeloma* Beds. The relative age of these two horizons was not known, but Ravn suggested that they were both Eocene — probably Lower Eocene. In the same paper a description of the sedimentary material attached to the fossils was given by N. V. Ussing, who showed that detritus from the break-up of granite-gneiss and basalt formed the bulk of the sediment. From the presence of fine-grained basalt fragments in the *Cyrena* Beds, Ussing inferred that "the eruption of the basalts had commenced before the deposition of the fossiliferous formations" (4, p. 101).

The re-examination of the Kap Dalton locality was made by my brother, Dr. H. G. Wager, and I, during the Scoresby Sound Committee's Second East Greenland Expedition under the leadership of Captain

Ejnar Mikkelsen (15 & 16) and a general statement of our results has already appeared (21). We spent only forty-eight hours at Kap Dalton, but they were hours of continuous light and we succeeded in determining the sequence of the Tertiary beds and in preparing a geological map from which the relationships of the sediments to the Tertiary basalts can be surmised. Our collection of marine fossils has already been examined by Professor Ravn (17) but, as suspected in the field, there are but few species not previously recorded. Professor Mathiesen will in due course describe the fossil plants. At the base of the Kap Dalton Sedimentary Series we discovered a conglomerate consisting entirely of pebbles of igneous rocks among which occur highly alkaline types. A considerable part of the present paper is devoted to a description of these rock types which have not been met with previously in the North Atlantic Tertiary Province.

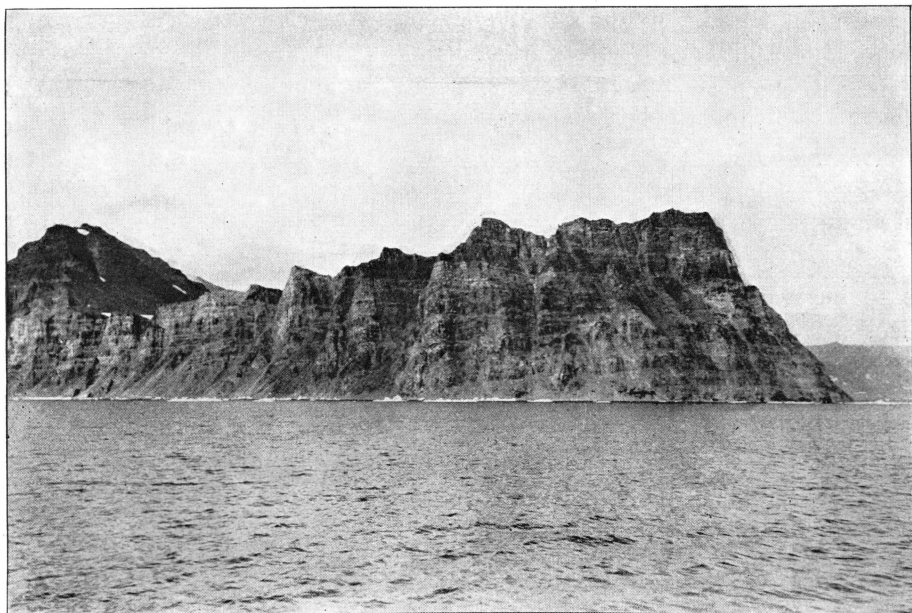


Fig. 1. The basalt headland of Kap Dalton from the South-West.

II. THE KAP DALTON SERIES

(a) Distribution and Sequence.

When approached from the sea, the actual headland of Kap Dalton stands up as an impressive red-and-black-banded cliff, one thousand feet high. Whereas the dip of the basalts along the 200 miles of coast from Kagerdlugsuak to the neighbourhood of Kap Dalton is uniformly to the S.E., the dip at Kap Dalton is to the NW and this is at once apparent even from a distance (Fig. 1). Behind the cape is a low neck of land with a lagoon and shingle beaches on its north side, and here is the anchorage and the house which was built by the Amstrup-Hartz expedition. About three quarters of a mile north of the house is a ridge trending in a westerly direction and averaging 1000 ft. in height; it is on this ridge that the main outcrop of the sediments is found (see Map, Plate 7). Another smaller out-crop occurs at about the same height and three quarters of a mile further to the NW. The former will be referred to as the main outlier and the latter as the subsidiary. West of the area of sediments the basalt mountains rise abruptly to 3000 ft.

In ascending the ridge from the house a succession of grass or scree covered terraces is crossed, due to the alternation of the resistant centres of the basalt flows with the less resistant amygdaloidal tops and red

partings. Only occasionally are exposures of the basalts to be seen. Oblique hollows or breaks in the regular arrangement of terraces are found which prove to be the result of faulting.

The ridge rises into three, indefinite, rounded summits. About 150 ft. below and to the SE. of the central summit, a scarcely cemented conglomerate, the lowest of the Tertiary sediments, just appears through a covering of soil and scree. The conglomerate is six feet thick and is composed of well rounded beach pebbles of various igneous rocks. A massive basalt, which is quite unweathered, occurs in situ twenty feet below the conglomerate. It is considered that this is not a sill but the centre of a basalt lava flow forming the local top of the basalt series, because (a) the lowest sediment is a conglomerate, (b) there is no hardening or other sign of metamorphism of the matrix of the conglomerate and (c) no sills were seen in the neighbourhood. The conglomerate has only been found at this one place although a well-cemented black pebbly sandstone occurs on the eastern summit of the ridge apparently near the base of the series.

Above the conglomerate is 60 ft. or so of brown to black shelly sandstone containing bands rich in *Cyrena gravesii* in the lower 40 ft. For this I propose to adopt Ravn's name of the Cyrena Beds. Five feet of more quartzose and less calcareous sandstone occur above. Then follows 15 ft. of brown to black sandstone containing fossil-wood fragments and indefinite nodular masses crowded with broken-up plant remains. These beds together with the basal conglomerate will be described as the Lower Series.

It must be explained that estimates of the thickness of the beds is only approximate and that even the sequence is still open to doubt. The sediments would be easily broken up by weathering in a temperate climate, but this happens intensively under arctic conditions, and débris from the sediments mixed with a few glacial erratics largely hides the rock in situ. From the rocky soil fossils can be collected easily and presumably this was the source of the bulk of the fossils brought back to Denmark by Hartz. Not only is there practically no exposure of the rock in situ, but the disintegrated rock, owing to violent solifluxion, is streaked out down the hillsides far from its original source. The streaks in the soil of a particular rock were at first taken to be some indication of the underground course of the beds, and it was not for some time that the utter unreliability of such evidence was realised. Added to these difficulties it is evident that there are rapid changes in strike and dip and that the area is cut up by faults. Boundaries which can be definitely seen are shown on the map differently from those which are inferred. The position of exposures of rock in situ is indicated on the map either by the continuous line of a definite boundary or by a dip arrow.

Above the lower series is a light yellow, friable sandstone about 50 ft. thick. This forms a small scarp on the central summit and, despite some false bedding, a reasonable idea of the dip can be obtained. This sandstone is the easiest unit of the Kap Dalton Sediments to map, as it tends to disintegrate less easily and large blocks of sandstone, such as occur for half a mile WSW. of the central summit, probably mark the approximate position of the bed.

A quarter of a mile west of the central summit is the lower and less definite western summit. Near the top, especially on the S. and SW. flanks, a large number of small nodules are scattered, most of which contain fossil crabs (*Coeloma bicarinatum*). On the NE. flank, also near the top there occur a few large, less definite nodular masses, often three feet in diameter, and these frequently contain the remains of a lobster (*Homarus Groenlandicus*). The various nodules are derived from a calcareous shale probably about 40 ft. thick which, following Ravn, will be called the *Coeloma Beds*, although the fossil crabs seem to occur mainly in the lower half. In the upper half are smaller nodules one to two inches in diameter, crowded with fragments of plants. Above the *Coeloma Beds* there are about 15 ft. of somewhat hardened white shale in which no fossils were found. The *Coeloma Beds* and the hardened shales lie above the middle series of yellow sandstone and are apparently the highest sedimentary beds in the district.

The exposures of the subsidiary outlier, which are even less satisfactory than those just described, occur on the northern side of another short eastward-trending spur. The locality was seen by Nordenskjöld and Hartz but was not examined. The yellow sandstone of the middle series was found in situ and dips obtained. Fragments of a dark sandstone believed to belong to the lower series were also seen.

(b) Petrology of the Sediments.

Two specimens of the *Cyrena Beds* and the nodules enclosing the fossils of the *Coeloma Beds* were petrologically examined by N. V. Ussing and an account given in Ravn's earlier paper (4, pp. 100—103). The results of an examination by Prof. O. B. Böggild of some of the sediments brought back in 1932 has been given in Ravn's later paper (17, pp. 6 and 7). Ussing considered that the material of the nodules of the *Coeloma Beds* originated exclusively from the destruction of Archaean rocks, while the sandstone of the *Cyrena Beds* was formed partly from these rocks and partly from the break-up of basalts, dolerites and some basic igneous rock rich in alkalies. He pointed out that the composition of the sediments proved that the extrusion of lavas had certainly begun in Lower Eocene time.

The pebbles of the basal conglomerate and the matrix surrounding them are described in a special section of this paper. One of the specimens of the Cyrena Beds described by Ussing, consisted solely of volcanic material and closely resembles the matrix of the conglomerate. It was presumably the presence of aegerine-augite and melanite garnet that suggested to Ussing the derivation of some of the material from "basic igneous rock rich in alkalies".

The material of the Cyrena Beds has been adequately described by Ussing. It consists apparently of the same minerals as are found in the matrix of the conglomerate diluted by variable amounts of sand derived from the break-up of the Metamorphic Complex.

The yellow sandstone forming the Middle Series has been examined in Reading University geological laboratory by Miss P. S. Walder, to whom I am indebted for the following observations. The sandstone is coarse, friable, free from carbonates and feebly cemented by hydrated oxide of iron which coats thinly most of the grains. Quartz fragments, only slightly rounded make up the bulk of the rock. Many show undulose extinction and in some silimanite needles were observed. Grains of fresh orthoclase, microcline, and plagioclase are common, as also are flakes of muscovite. Separation of the heavy minerals with bromoform gave an abundant crop of large grains showing no evidence of a lengthy period of transport. The heavy minerals in order of abundance are:—

1. Garnet. This makes up more than half of the total heavy minerals. It occurs in angular chips of various degrees of pinkness.
2. Staurolite.
3. Tourmaline. The commonest type is brown in colour.
4. Sphene.
5. Rutile, deep, foxy red variety.
6. Magnetite.
7. Ilmenite and leucoxene.
8. Epidote.

There are also certain doubtful grains, one ascribed to topaz and another to kyanite. As with the leucocratic minerals it is clear that the heavy minerals also come mainly from the break-up of the East-Greenland Metamorphic Complex.

The marly concretions of the Coeloma Beds consist of angular fragments of quartz and felspar with flakes of muscovite and biotite set in a base of carbonate, grey with argillaceous material. The fragments of quartz and felspar have an average grain size of only a fifth of that of the Middle Series sandstone. Much of the carbonate material shows organic structures.

The highest sediments now preserved in the district are of white hardened shales. From their appearance it is tempting to believe that they have been baked, but there is no internal microscopic evidence of this or any intrusion now preserved which might have produced the effect. I do not agree with Prof. Böggild (17) that this is a metamorphosed tuff, but consider it a sediment of unusual appearance under the microscope. An isotropic chloritic material apparently forms the bulk of the rock.

(c) The Fossils.

In the Cyrena Beds marine fossils are found abundantly, and they occur, but in less numbers in the upper part of the lower series. No fossils have been found in the middle series and, in the upper series, marine fossils are confined to the lower part. All the marine fossils collected on the two expeditions which have visited Kap Dalton have been examined in detail by Ravn and lists and descriptions have been given by him (4 & 17).

Fossil wood from Kap Dalton was described some years ago by Mathiesen (13) but the exact horizon of the specimens was not known. The new material, collected in most cases from a definite bed, has also been handed to Professor Mathiesen for examination. The coarse, pebbly, black sandstone on the west flank of the eastern summit (Pt. 300 m), believed to be near the base of the series, contains abundant fragments of wood. A large, calcified, base of a tree at least eighteen inches in diameter and other large chunks occurred in a black sandstone NW. of the outcrop of the Coeloma Beds in what is also believed to be the lower part of the Lower Series. Fossil-plant fragments occur abundantly in the top fifteen feet of the lower series where this bed is exposed on the central summit. Calcified and teredo-bored wood occurs in the upper series, but as it was not found in position it is not known in which part. The small nodules near the top of the Coeloma Beds also contain wood fragments.

The marine fossils are, according to Ravn, identical or closely related to species from the Eocene of the London and Paris Basins; the fauna is considered to prove that the beds are Lower or Middle Eocene, more probably the former. The plant remains previously collected from Kap Dalton are considered by Mathiesen to be early Tertiary like those from Sabine Island. An insect wing from Kap Dalton has been described by Henriksen (7) and is said to be a Middle Eocene species.

(d) The Structure and its bearing on the Age of the Plateau Basalts.

The structure of the Kap Dalton area must be largely a matter of conjecture owing to the poorness of the exposures. There is certainly

some folding and the main outlier is interpreted as essentially a basin elongated in a NNE.—SSW. direction. The area is, however, much cut up by faults and these, rather than the folding, are probably mainly responsible for the present lie of the rocks.

In the coastal cliffs, a quarter of a mile NNW. of the house there is a conspicuous normal fault which has a hade of 10° to the SE. and a throw of 40 ft. Mapping proves that the lower part of the ridge between the east and central summits is caused by a fault with down throw again to the SE. Where the fault is cutting the sediments the amount of throw is approximately 60 ft. At its NE. end the fault has caused a subsidiary hillock of basalt to be formed to the WNW. of Point 300 m. The valley between the main and subsidiary outcrops probably marks the position of at least two faults; one throwing to the SE. is required to explain

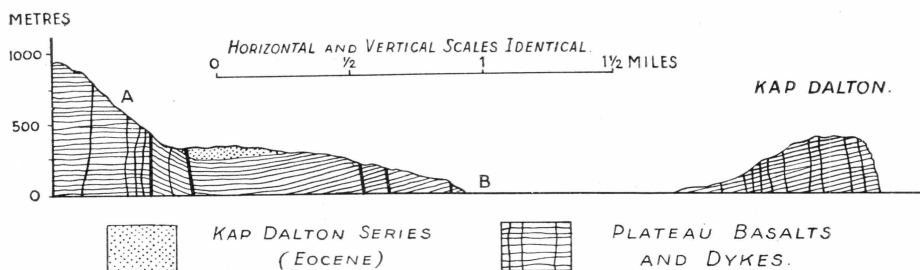


Fig. 2. Cross-section showing the sediments at Kap Dalton preserved by faulting as a synclinal outlier. Points A and B are marked on the map, Plate 7. Faults are shown by thick lines.

the relationships of the sediments at the west end of the ridge; another, conjectural in direction, seems to be required to bring up the subsidiary outlier into its present position.

Two other faults are also indicated on the map. One is entirely in the basalts to the S.E. of the sediments and its presence is suggested by a hollow, breaking obliquely across the terracing of the hillside. The other lies along the foot of the 3000 ft. mountain to the west of the outcrops of the sediments. The dip and strike of the yellow sandstone of the subsidiary outlier is modified in a way which suggests that the rocks have been up-turned by a fault with up-throw to the west; along the assumed position of the fault crushed and slickensided basalt are found. This fault, which is believed to be the most important in the district, runs in an approximately N.-S. direction. The sediments do not appear in the cliffs forming the east and north face of the 3000 ft. mountain and it is believed that the N.-S. fault has an up-throw to the west of 1500—2000 ft., which is the amount required to explain the absence of sediments in the face of the mountain. As is so often the case a fault, considered of most significance, is the most difficult to prove. Two

additional facts suggesting its importance are (a) the concentration of dykes immediately to the west of the fault and (b) the horizontal lie of the basalt west of the fault as compared with the fairly steady dip of 10° on the slopes below the sediment and on the cape itself (Fig. 2).

The preservation of the Kap Dalton sediments is considered to be due to down-faulting which has protected them from complete removal by erosion. It is believed that the sediments once overlay all the basalts now found in the district, and that the basalts are therefore earlier in age than the sediments. The unweathered state of the basalt immediately below the sediments (mentioned on p. 8) suggests that there was no great interval of time between the extrusion of the basalt and the deposition of the sediment. Thus the highest basalts of the Kap Dalton area are, with a high degree of probability, Lower Eocene in age.

III. PETROLOGY OF THE BASALTS UNDERLYING THE KAP DALTON SERIES

Large geodes of chalcedony and quartz are scattered widely among the earth and scree formed from the first few hundred feet of basalts below the sediments. In the field it was suspected that these basalts were tholeitic and this has been confirmed by microscopic examination. The basalt collected immediately below the Kap Dalton sediments contains a considerable amount of interstitial glass and the same is true of the basalt collected 100 ft. below the sediments.

The nonporphyritic, tholeitic basalt, E.G.1057¹⁾, collected 100 ft. below the sediments on the SE. flank of the central summit gives the following composition by volume on microscopic analysis:

Plagioclase.....	35 %
Pyroxene.....	29 -
Iron Ore.....	7 -
Chlorite and Glass.....	29 -

This rock has been analysed by Dr. H. F. Harwood (21, Anal. I, Table 1, p. 32) and for convenience this analysis and the calculated norm are repeated here (Tables I and II). Drawings of the rock as seen under the microscope have been made by Mrs. C. T. Ingold (Figs. 3A and 3B).

The plagioclase, where it projects into glass or chlorite areas, has its characteristic rectangular shape; where in contact with pyroxene neither mineral has its own shape, and clearly the pyroxene and plagioclase crystallised mainly simultaneously. There is a slight zoning of the plagioclase, but away from the narrow outer zone its composition, by the method of the maximum symmetrical extinction angle, is Ab 33%, An 67%. This corresponds approximately to the molecular proportion of albite and anorthite in the norm.

¹⁾ These figures refer to the catalogue number of specimens at present in the Museum of Reading University.

The pyroxene seems to be of one kind only, and like the felspar, where it is in contact with the glass or chlorite, it may show something of an euhedral form. Owing to the small size of the crystals it is not easy to determine the optic axial angle accurately, but $2V$ is in the neighbourhood of 60° . The pyroxene is not therefore a pigeonite and it must be assumed that the constituents, calculated as hypersthene in the norm, actually occur in the chlorite and glass.

The iron ore, probably titaniferous magnetite, often shows skeletal

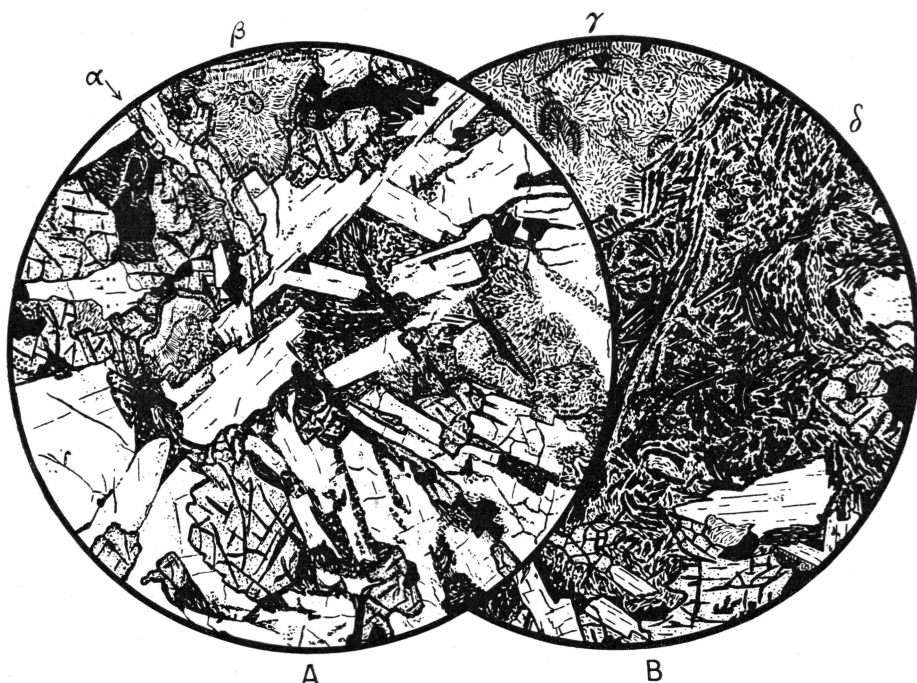


Fig. 3. Tholeiitic basalt (E. G. 1057) — analysed specimen, 100 feet below the lowest sediment, Kap Dalton, East Greenland. A, Section of typical rock — α , chlorite replacing olivine — β , interstitial chlorite. B, Part of vesicle — γ , chlorite at centre of vesicle — δ , glass of marginal part of vesicle with rods and skeletal growths of iron ore. Magnification $\times 125$.

forms. It was one of the later minerals to crystallise, occurring sparingly in the outer part of the plagioclase or pyroxene crystals and abundantly in the surrounding glass and chlorite areas. Fine rods of iron ore or delicate skeletal growths occur in the glass.

The glass together with chlorite occupies the interstices. The colour of the glass is dark brown and its refractive index is greater than Canada Balsam. Acicular crystals, probably apatite, and opaque crystals of iron ore are abundant in it.

Chlorite occurs interstitially in considerable quantities and it also

occurs, but only in small amounts, totally replacing olivine. The interstitial patches of chlorite may be brown or green in colour; they consist of flaky crystals set at right angles to the walls of the interstice. Growth of the chlorite crystals has taken place from the walls towards the centre of the cavity and dark zones parallel to the walls mark the periodic deposition of fine ferruginous material. In some cases the chlorite contains the same apatite and iron ore inclusions as the glass and is in these cases clearly replacing original glass. The chlorite often occupies the centre of an interstice whose margin is glass and this arrangement may be shewn by the vesicles. (Fig. 3B).

The chlorite replacing olivine may also be brown or green and is the same mineral as that in the interstices, but the flakes are not set regularly at right angles to the margin of the former olivine, and dark zones parallel to the margins do not occur. It is not easy to decide how much former olivine was present in the basalt but probably 5 or 7 %. In the closely similar rock (E.G.1056), occurring immediately below the sediments, a few grains of fresh olivine were found but most of the olivine has been replaced.

The formation of chlorite took place after the solidification of the glass when (probably after the temporary intervention of a vapour phase) a residue became still richer in water. Since, in some cases only partial replacement of the glass by chlorite has taken place, the factor limiting the change is presumably the shortage of water, and since the chlorite replacing olivine is the same as that in the interstices it is reasonable to assume that the replacement of the olivine was also a late stage effect.

In the available specimens, vesicles are rare. Chlorite, calcite, chalcedony and quartz are the only vesicular minerals which have been observed.

Only one other basalt, namely E.G.1056, on which the sediments actually rest, was collected from those which can definitely be asserted to lie close under the sedimentary series. This basalt is strikingly like the one just described, the main difference being that the glass is a little less abundant and lighter in colour.

The analysis and description of the Staffa Type of basalt given by the Authors of the Mull Memoir (9) differ in no essential from that just given of the basalts from Kap Dalton. The Staffa Type is regarded as the more basic end of the Nonporphyritic Central Type of basalt. Some of the dykes from the region between Kap Dalton and Kap Daussey, when judged by microscopic appearances, seem to be formed from a similar magma. Analyses of two other basalts collected south of Kap Dalton are given in a previous paper (21, Analyses II and III, p. 32). These differ somewhat from that of the Kap Dalton Basalt and seem in fact to be a mean between the Nonporphyritic Central Basalts and the Plateau

Basalts as defined in the Mull Memoir. G.W. Tyrrell (14) has described a basalt from the Tertiary igneous region north of Scoresby Sound which is closely comparable with the tholeitic basalt from Kap Dalton (Table I, Anal. B). A similar magma occurring as a sill in the same district has been described by Backlund and Malmqvist (12) (Table 1, Anal. c). The latter authors have attempted to define the magma types of the East Greenland basalts. There is at present insufficient data for an adequate treatment of this kind in the case of the basalts forming the peninsula between Kangerdlugsuak and Scoresby Sound, and this is by far the largest basalt area of East Greenland.

Three specimens of basalts from the coastal cliffs immediately

TABLE I.
ANALYSIS OF BASALTS.

	A.	B.	C.	D.
SiO ₂	48.89	48.64	48.20	53.00
Al ₂ O ₃	13.60	12.62	11.97	22.70
Fe ₂ O ₃	4.72	4.34	4.52	2.43
FcO	9.65	7.34	11.65	1.49
MgO	4.54	7.33	4.94	.12
CaO	10.09	11.85	10.21	1.00
Na ₂ O	2.74	1.85	2.39	10.20
K ₂ O	.30	.31	.79	2.35
H ₂ O+	1.38	1.05	.62	5.90
H ₂ O—	1.14	2.25	..	.35
CO ₂	.02	trace	none	none
TiO ₂	2.64	2.20	3.01	.15
P ₂ O ₅	.39	.18	.92	none
Cl ₂	trace	..	..	..
S	.02	none	..	none
MnO	.24	.12	.40	.15
SrO	trace	..	..	..
BaO	trace	..	none	..
Li ₂ O	trace	..	..	..
	100.36	100.08	99.62	99.84
Spec. Grav.....	2.90	..	2.997	..

- A. Tholeitic Basalt (E.G. 1057) Kap Dalton, East Greenland, Hill west of anchorage and 100 ft. below lowest sediments. Anal. H. F. Harwood. (Quoted from 21, p. 32).
- B. Basalt lava (86), summit of Jackson Island, Gael Hamkes Bay, East Greenland. Anal. F. Herdsman. (Quoted from 14, p. 522).
- C. Dolerite Nr. 141, the coast near Kirchenpauer Bucht, Claverling Is. Anal. N. Sahlborn. (Quoted from 12, p. 24).
- D. Erratic (EG. 1289). Probably altered phonolite. Narrow valley east of Notch Mountain on the west side of Kangerdlugsuak, East Greenland. Anal. W. H. Herdsman. (Quoted from 21, p. 32).

north of the small fault which passes out to the coast a quarter of a mile NE. of the Kap Dalton house, have been examined. If we follow the interpretation of the structures already given these basalts lie below the sediments, but it is impossible to estimate how much below owing to doubt of the number and amount of throw of the faults in the intervening country.

These basalts, even in hand specimens, can be seen to be appreciably more altered than those immediately below the sediments. Under the microscope they are seen to have microporphyritic augite and feldspar. The augite has a fairly high 2 V and is not pigeonite, the feldspar is dominantly labradorite, former olivine was probably more abundant than in E.G. 1056 and 1057, chlorite occurs interstitially and perhaps some glass. Since these basalts may not be at all closely comparable in horizon with the tholeiitic basalts from immediately below the sediments they will not at present be described in detail.

TABLE II.
NORMS OF BASALTS.

	A.	B.	C.	D.
Quartz.....	4.5	4.9	3.48	..
Orthoclase.....	1.8	1.7	5.00	13.6
Albite.....	23.4	15.7	20.44	51.0
Anorthite.....	23.7	25.3	19.46	5.0
Nepheline.....	..	..	..	20.8
Corundum.....	..	..	..	1.6
Diopside.....	21.7	26.3	20.86	..
Hypersthene.....	10.5	12.0	15.57	..
Olivine.....	..	..	..	.8
Magnetite.....	6.7	6.3	6.50	3.5
Ilmenite.....	5.1	4.3	5.78	.2
Apatite.....	.5	.3	2.02	..

IV. THE PEBBLES OF THE BASAL CONGLOMERATE OF THE KAP DALTON SERIES

The interest of these pebbles was not realised in the field and only two or three handfuls were brought back to Europe. During a hurried examination in Greenland they appeared to be mainly weathered basalts and basaltic dyke-rocks. A more careful examination later showed the presence of a gabbroic rock and a microscopic examination has revealed an almost pure assemblage of highly alkaline igneous rocks. In 1934 I had hoped to have an opportunity, as a member of Dr. J.-B. Charcot's expedition on the S. S. *Pourquoi Pas?*, to make a larger collection of the pebbles, but the bad ice made it impossible to reach this part of the coast.

The conglomerate, which appears to be only about six feet thick, consists of pebbles whose average size is five centimetres in length, the largest which was brought back being twelve centimetres. A coarse black sand (grain size about .5 mm) forms the matrix in which the pebbles lie, and it is just sufficiently cemented with calcite to allow a section to be cut without impregnation.

An examination of the mineral composition of the matrix of the conglomerate was undertaken by Miss P. S. Walder at Reading University in the hopes that rare minerals associated with alkaline igneous rocks might be found. A somewhat similar pebbly black sand but more firmly cemented occurring on the NW. slope of the eastern summit (Pt. 300 m), presumably near the base of the series, was also examined. The usual separation into heavy and light fractions was found to be of little use because these sands are about equally rich in heavy and light minerals. If any rare heavy minerals exist they have remained hidden among the dominant pyroxene and iron ore fragments.

In the matrix of the conglomerate the following minerals have been noted:—

1. Three varieties of pyroxene — a greenish or brownish augite, a titaniferous augite and aegerine.
2. Ilmenite and magnetite, both partly leucoxenised.

3. Several grains of very well rounded monazite.
4. Apatite.
5. Two flakes of muscovite.
6. Orthoclase.
7. A colourless isotropic substance with refractive index well below Canada Balsam and believed to be analcite.

The pyroxene and iron ores were by far the most abundant fragments. The monazite grains were smaller and much more rounded than any of the other minerals and seem to have a different provenance. Besides the mineral fragments there is an equal bulk of small rock fragments which seem to be mainly fine-grained soda-trachyte and trachy-andesite.

The minerals in the black sandstone from Pt. 300 m are essentially the same and occur in the same order of abundance, except that a grain of melanite garnet was found but no monazite. In a thin section of this rock several grains of melanite are to be seen and also several of sphene. It is more satisfactory to examine the heavy mineral content of this sand by means of sections than by separation of the heavy constituents, because it is practically a concentrate of heavy minerals already. Among the abundant rock fragments about half can be interpreted as the chilled phases of types occurring as pebbles in the conglomerate, the others seem to be the chilled phase of a normal basalt, a type which has not so far been found among the conglomerate pebbles. An interesting feature to be seen in thin sections of this sandstone is the partial, but clear-cut, replacement of aegerine or aegerine-augite grains by carbonates.

Dr. G. W. Tyrrell of Glasgow University, who described (14) the Tertiary igneous rocks collected by Mr. J. M. Wordie in 1926 in the region north of Scoresby Sound (10), has kindly looked through all the sections of the Kap Dalton pebbles. Only rarely was there any close similarity between the rocks collected by Wordie's expedition and those from which the pebbles were formed. In many cases a name suggested by Dr. Tyrrell has been adopted and his comments have been largely quoted in what follows.

One of the pebbles collected at Kap Dalton is a plutonic rock and this will be described first; then six pebbles believed to be from sills or dykes, and finally the remaining ten, which are believed to be lavas. It should be noted however that it has not always been possible to discriminate between hypabyssal rocks and lavas.

(a) Malignite.

In hand-specimen this rock, EG. 1047, is seen to have a gabbroic texture, the pyroxene crystals attaining $\frac{1}{2}$ cm in length.

In thin section the pyroxene and nepheline, each forming about

a third of the total rock, can be seen to be idiomorphic (Plate 1, Fig. 1). The pyroxene is a strongly pleochroic, purple augite containing abundant iron ore and apatite inclusions. It is partly altered to a dark brown hornblende, and small patches of the same hornblende, widely scattered through the rock, are allotriomorphic towards all minerals except the analcite.

The nepheline occurs in crystals only a little smaller than the pyroxene and is fresh except for slight decomposition picking out the 1010 cleavage. Orthoclase, about half as abundant as the nepheline and slightly dusty with decomposition products, surrounds the nepheline but is idiomorphic towards the analcite. There is no irregular extinction which would suggest an approach to microperthite to be seen in the orthoclase. Analcite occurs in sporadic interstitial patches and forms perhaps a twelfth of the whole rock.

Iron ore occurs as somewhat rounded crystals and may be bordered by sphene. Sphene also occurs as separate units but always in association with the iron ore. Apatite in euhedral crystals is abundant.

The name malignite is adopted for this rock, although differing in some ways from the type malignite of Lawson (2). In Lawson's specimens the pyroxene is aegerine, nepheline is surrounded poecilitically by orthoclase and analcite was not observed.

(b) Tinguaitite.

In the first specimen to be described, E. G. 1047B. (Plate 1, Fig. 2), the phenocrysts in order of abundance are nepheline, orthoclase, decomposed nosean, aegerine and rare sphene and apatite. The well-shaped nepheline crystals attain .5 cm in length and are only partly decomposed. Roughly hexagonal cross-sections of some mineral now completely decomposed are believed to represent former nosean. At first these were thought to be cross-sections of nepheline but the proportion of rectangular and hexagonal cross-sections is unreasonable on this assumption. The orthoclase occurs in rare — but large — tabular crystals attaining 1 cm in length. These, like the nepheline, are only partly decomposed. The aegerine phenocrysts are well-shaped, acicular, six-sided prisms. Sphene in large well-shaped crystals, and apatite also showing crystal shape, are of sporadic occurrence.

The ground mass is much decomposed. Rare lath-shaped sections showing repeated twinning are of acid plagioclase. Somewhat rounded polygonal sections free from aegerine are considered to be completely decomposed nepheline or leucite. Surrounding these units of the ground mass is a colourless decomposition product, partly carbonate, which is crowded with small interlacing needles of aegerine.

Another tinguaitite, E.G. 1047 J (Plate 2, Fig. 1) ¹⁾ has the following phenocrysts in order of abundance: titaniferous augite, decomposed nepheline, brown hornblende, iron ore, apatite and sphene. The augite, in euhedral crystals, attains .2 mm in length and is strongly purple and pleochroic. The nepheline also occurs in well-shaped crystals but is completely decomposed. The brown hornblende occurs sporadically in somewhat rounded crystals.

The ground mass consists of small columnar crystals of greenish pyroxene and dark brown hornblende surrounded by indeterminate colourless material.

Both these specimens are named tinguaitite, being regarded as hypabyssal rocks because of the interlacing ferromagnesian minerals in the ground mass. The second rock is much richer in melanocratic constituents than the first and is transitional to the rocks described below as pyroxene-monchiquite.

(c) Pyroxene-monchiquite.

In hand-specimens the three pebbles, E. G. 1047 O, P, and Q, look like much-weathered basalts. In all three there are microphenocrysts of pyroxene, decomposing iron ore and apatite.

Under the microscope the larger pyroxenes of E. G. 1047 Q (Plate 2, Fig. 2) are seen to be strongly zoned, having intense green centres and purplish margins. Microphenocrysts of apatite are rare. The ground mass consists of a mat of columnar, purple augite crystals and iron ore, half altered to brownish sphene, set in a colourless base which, at any rate partly, may be analcite. Pyroxene forms at least two-thirds of the total rock.

The rare microphenocrysts of pyroxene in E. G. 1047 P (Plate 3, Fig. 1) are faintly purple. Stumpy purple pyroxene crystals form half the ground mass. The pyroxenes and small abundant crystals of iron ore — not in this case altered to sphene — are surrounded by a colourless base which is largely isotropic and therefore probably analcite. E. G. 1047 O is a closely similar rock but finer-grained. Characteristic of both the last two rocks are frequent patches of analcite with connecting pipes which are well seen in the photograph (Plate 3, Fig. 1).

The above rocks are of monchiquite type but it is difficult to assign to them an exact name because the nomenclature of the whole group requires revision. Rosenbusch did not consider that olivine was, an essential constituent of the monchiquites and A. Holmes ²⁾ in a brief

¹⁾ The magnification of this and the following photomicrographs is $4\frac{1}{2}$ times those of Plate I.

²⁾ Holmes, A. "A contribution to the petrology of North-Western Angola". Geol. Mag. Dec. VI. No. VII, pp. 326—328. 1915.

rediscussion of the classification of the group has followed him. The abundance of titaniferous augite and the absence of any amphibole have been the dominant considerations in adopting the name pyroxene monchiquite for the rocks here described. The unsatisfactory name fourchite has been given by J. F. Williams¹⁾ to certain rocks from the Fourch Mountains, Montana, which are apparently olivine-free, augite-rich monchiquites. The type specimens however are so decomposed that their original chemical and mineralogical composition is open to doubt and it seems inadvisable to continue to use the name.

(d) Hornblende-kersantite.

Sporadic tabular plagioclase crystals, iron ore and some decomposed ferromagnesian mineral occur as phenocrysts (Plate 3, Fig. 2). The plagioclase, by the method of maximum symmetrical extinction angles, has been determined as oligoclase-andesine; it is dusty with decomposition products and is in places completely replaced by epidote. The iron ore, in well-shaped crystals, is presumably magnetite. Green and almost isotropic chlorite with some sphene have completely replaced phenocrysts of some ferromagnesian mineral whose original nature is in doubt.

The ground mass consists of hornblende, iron ore and granular sphene surrounded by feldspar. There seems to be no difference in refractive index between the feldspars forming the phenocrysts and those of the ground mass, and both are dusty with inclusions. The ground mass feldspars are therefore believed to be oligoclase-andesine. They occur in tabular crystals with indefinite boundaries showing, under crossed Nichols, a criss-cross pattern. The abundant hornblende of the ground mass is in the form of brown acicular crystals.

The rock is apparently a kersantite. It has no definite alkaline characteristics and may not be closely related to the highly alkaline rocks of which the majority of the pebbles are composed.

(e) Soda-trachyte.

In E. G. 1047C, the first of the lavas to be described, rare phenocrysts of oligoclase-andesine and iron ore occur in a base of trachytic texture consisting of plagioclase, iron ore and chlorite (Plate 4, Fig. 1). The ground mass plagioclase laths with fluxion arrangement, have a refractive index which suggests that they also are oligoclase-andesine. No orthoclase or quartz can be detected. The iron ore occurs in irregular, often minute, pieces and the chlorite, which forms only about five percent. of the total rock, occurs as sporadic flakes which may or may not be replacing some other mineral.

¹⁾ Williams, J. F. Geol. Surv. Arkanas Ann. Rep. II, p. 107. 1890.

(f) Trachy-andesite.

This rock, E. G. 1047 F (Plate 4, Fig. 2) has occasional augite phenocrysts up to .5 cm in length and smaller phenocrysts of iron ore. The augite phenocrysts are faint green near the centres and purple and pleochroic near the margin. The ground mass consists of lath-shaped plagioclase, about oligoclase-andesine, with granules of purplish augite, iron ore and flakes of biotite.

Two other rocks are also classified as trachy-andesite. In E. G. 1047 L, microphenocrysts of strongly purple augite are set in a ground mass similar to that of the trachy-andesite figured, except that biotite is not present, although patches of chlorite may replace that mineral. E. G. 1047 N contains microporphyrritic purplish augite in a base similar to that of the trachy-andesite figured, but richer in augite.

(g) Trachy-basalt.

Dr. Tyrrell has described a trachy-basalt of Dunsapie type from Hold with Hope, East Greenland (14), and he says of the pebble E. G. 1047 E (Plate 5, Fig. 1) that it compares well with his rock from further north. Phenocrysts of zoned, greenish to purplish augite over 1 cm in length occur with more abundant but smaller phenocrysts of andesine-labradorite which attain .3 cm in length. Some patches of dark brown serpentine apparently represent former olivine. Together the phenocrysts make up half the rock.

The ground mass consists of smaller plagioclase and augite crystals surrounded by less definite feldspathic material and glass. Skeletal, leucogenised iron ore is abundant in the glass. Unlike Dr. Tyrrell's rock there is neither biotite in the ground mass nor vesicles containing analcite.

(h) Analcite-rich trachy-basalt.

The largest crystals in this fine-grained rock E. G. 1047 G (Plate 5, Fig. 2), are of apatite which attain half a millimetre in length. These together with iron ore are regarded as microphenocrysts. The apatite is remarkable in appearance because it is crowded with rods of magnetite arranged parallel to the hexagonal axis. The magnetite inclusions are so abundant near the margin that the crystal is almost opaque.

The ground mass consists of light green, stumpy rods of augite, euhedral iron ore and occasional flakes of biotite set in a base of analcite and lath-shaped untwinned feldspar. Analcite and a radiating, acicular zeolite occur in evenly-spaced patches throughout the rock.

The naming of this rock is difficult as the nature of the feldspar has not been satisfactorily determined. An analysis might well show that the rock is sufficiently alkaline to be named a phonolitoid tephrite.

The microphenocrysts of apatite crowded with inclusions of iron ore make this rock an easily recognisable type.

(i) Leucite-nephelinite.

The only large crystals in this rock, E. G. 1047M (Plate 6, Fig. 1), are of intensely purple and pleochroic augite attaining half a centimetre in length. Iron ore, perovskite and apatite are also present as early formed crystals.

Fairly large, fresh, euhedral crystals of nepheline and leucite occur abundantly and may be considered as microphenocrysts. Surrounding these is the true ground mass of acicular, purple and pleochroic pyroxenes with a few crystals of iron ore set in a colourless material which seems to be largely nepheline.

Dr. Tyrrell agrees with the name leucite-nephelinite for this rock, but because of the network of acicular pyroxenes in the ground mass he would suggest that it may be a hypabyssal rock related to the tinguaites.

(j) Nepheline-leucitite.

In this rock, E. G. 1047M (Plate 6, Fig. 2), there are abundant but completely decomposed phenocrysts of nepheline attaining 2 mm in length. There are also small phenocrysts of aegerine-augite, iron ore and sphene.

The ground mass formerly consisted of leucite and aegerine crystals in a leucocratic base. Leucite probably formed three-quarters of the total ground mass but is now completely decomposed. Extensive patches of a single crystal of a some colourless mineral, probably orthoclase, replace the leucite and enclose the small aegerine crystals. The latter, together with the sporadic sphenes are, therefore, the only original minerals remaining undecomposed.

V. CONCLUSIONS

In 1822, on the south side of Scoresby Sound, William Scoresby discovered brown coal which was evidently derived from an inter-basaltic layer (1, pp. 221—222). This locality has not yet been described in detail, but Nordenskjöld has stated briefly (5, p. 220) that between the basalts there is a thin horizon of true tuffs and sandstone. In 1900, during the journey southwards down the coast, Nordenskjöld found sediments at Turner's Sound, though he did not examine the locality in detail (5, p. 191). He also discovered the Kap Dalton occurrence which was the most southerly point reached by him. The coast south of Kap Dalton was first examined geologically by me during the Scoresby Sound Committee's 2nd East Greenland Expedition. No trace of sediments was found, or of faulting and reversed dips which are features associated with the sediments at Kap Dalton. It is concluded, therefore, that all the basalts south of Kap Dalton are younger and underly the Lower Eocene sediment. I have suggested (21, p. 33) that between Lat. 69° and $69^{\circ}30'$, and perhaps also more widely, a dominantly porphyritic series of basalts lies below a dominantly nonporphyritic. To the north of Kap Dalton, Nordenskjöld states that "porphyritic basalts play only a small part among the nonporphyritic" (5, p. 220). Perhaps between Kap Dalton and Kap Brewster only the higher, nonporphyritic basalt horizons are exposed, and it seems probable that a basalt series lying above the apparently widespread sedimentary deposits exists there.

The sudden, extensive reversal of the dip at Kap Dalton which all the way from Kangerdlugsuak to this point is constantly seaward, must be taken to indicate an important change in tectonic conditions. The seaward dip is clearly the result of the sinking of the Denmark Strait with concomitant rise inland. The same general crustal movement seems to have acted at Kap Dalton though the structures in the rocks are different. Two opposed effects are there seen — dips to the NW. and faults throwing down to the SE., the effect of the latter dominating.

The final result, therefore, is the same as further south, namely, a general sinking of the crust towards the Denmark Strait.

The change in the effects produced by the same regional crust movement must be due to some special influence at work locally. Perhaps the N.-S. Jameson Land syncline continues southwards from Scoresby Sound to the Kap Dalton area. Unfortunately, no dips have been recorded for the basalts along the south side of Scoresby-Sound or between Kap Brewster and Kap Dalton, but Nordenskjöld observes (5, p. 220) that the interbasaltic horizon of tuffs and sandstone on Kap Brewster sinks slowly towards the W., an observation in conformity with the views here expressed. This region is relatively accessible and more work is desirable as the post-basalt age of the Jameson Land syncline will imply the post-basalt uplift of the Liverpool Coast.

The Kap Dalton Series is only 150—200 ft. thick and yet it contains sediments of different types and of completely different provenance. The basal conglomerate, clearly a beach deposit, was derived from a land on which occurred only alkaline lavas, dykes and sills, with occasional, related plutonic rocks. The few monazite grains in the matrix of the conglomerate form an exception to this general statement; perhaps they were blown there by winds from some distant region. With further sinking of the area the Cyrena Beds were deposited; the sandy materials forming them were derived partly from a basalt area and partly from the erosion of a metamorphic region or of sediments derived themselves from metamorphic rocks. Then during the deposition of the Middle Series, conditions changed again and only detritus derived directly or indirectly from the Metamorphic Complex entered the district; at the same time the shelly fauna disappeared. The Upper Series is also composed of detritus from the Metamorphic Complex. Although the Upper Series is finer grained than the Middle, it was presumably not deposited in deeper water because of the unworn, and therefore undrifted, remains of crabs, which were presumably shallow water creatures; and also because ripple-marked calcareous muds occur. Higher horizons have not been found at Kap Dalton, but if the sediments there are to be correlated with those at Turner Sound and Kap Brewster, renewed extrusion of basalts apparently took place after the sedimentary phase.

It is difficult to understand how basalt detritus could be so completely excluded from the Middle and Upper Series at Kap Dalton unless all the basalts of the huge area to the West and North were at that time covered by the sea. If this had happened, it is surprising that the sea at Kap Dalton, which would then be far from the coast, remained apparently shallow. The most satisfactory hypothesis to explain the facts seems to be that the Jameson Land syncline was already active

and uplift of Liverpool Land had also begun. We shall see below that there is some evidence that the alkaline basalt etc. of the basal conglomerate came from lavas which once covered the region about the entrance to Davy Sound. When these had been removed, Mesozoic sediments below the basalts, and at a later stage the Metamorphic Complex of Liverpool Land itself, would provide the material which forms the Middle and Upper Kap Dalton Series.

Turning now to the problem presented by the pebbles of the basal conglomerate, it is clear that the region from which they were derived consisted solely of lavas, dykes, sills, and related plutonic rocks; even the matrix of the conglomerate contains no detritus from the Metamorphic Complex with the exception of the monazite noted above. Although I am aware that pebbles of hypabyssal rocks occur in the Triassic Conglomerate north of Scoresby Sound (5, 11) thus proving a pre Triassic and probably Hercynian igneous activity, there can be no reasonable doubt that the homogeneous alkaline suite of pebbles in the Kap Dalton Conglomerate came from some part of the late Cretaceous or early Tertiary igneous field of East Greenland.

In no case has one of the more highly characteristic types from the conglomerate yet been found in situ anywhere in Greenland. The specimen of trachy-basalt collected by Wordie from Jackson Is., Gael Hamkes Bay and described by Tyrrell (14) is similar to, but not identical with, the trachy-basalt pebble E. G. 1047 E. Unfortunately this is one of the less characteristic types and there is no great likelihood that the Gael Hamkes Bay region is the source of the pebbles.

Although in the area between Kap Dalton and Angmagsalik which I have personally examined, there are nepheline syenites and other highly alkaline plutonic rocks, no volcanic or hypabyssal rocks at all closely comparable with the Kap Dalton pebbles were found in situ. However, on Notch Mountain in Kangerdlugsuak, some hundreds of feet above sea level one erratic was found, which is a highly alkaline, fine-grained rock (Analysis D, Table I, p. 17). Unfortunately the single specimen is much decomposed; in the ground mass is abundant fresh acicular aegerine and pseudomorphs undoubtedly after nepheline; this surrounds phenocrysts which from their shape suggest one of the isotropic feldspathoids. It is not clear whether the rock is a lava flow or hypabyssal injection, but in my opinion, the former is more likely. Possibly during some considerable submergence of the Kangerdlugsuak area the erratic was brought by sea ice but on the whole I incline to the view that it was transported by land ice from the region to the N. of Kangerdlugsuak. Lieut. Martin Lindsay's expedition in 1934 collected only five rock specimens from the region whence this pebble might reasonably have been brought by ice. I have been privileged

to see these specimens and they have an alkaline tendency but nothing approaching the alkalinity of the erratic. In Kangerdlugsuak itself rare, highly alkaline, dyke rocks have been found, but again nothing at all closely comparable with such Kap Dalton pebbles as have so far been collected.

It seems likely that the origin of the pebbles must be sought in the region to the north of Kap Dalton. The currents on the East side of extensive land masses stretching in a N.-S. direction into the Arctic Sea are nowadays always southerly, and it is likely that similar currents brought the Kap Dalton Eocene deposits from the North.

North of Scoresby Sound various alkaline intrusive rocks have been collected by Nathorst, Nordenskjöld, Wordie, Koch and A. Noe-Nygaard. Backström (6) described a rock collected by Nathorst as tinguaitite-like, and an erratic from Fame Island as monchiquite. From Cape Fletcher, Nordenskjöld collected rocks of lamprophyric and nepheline-tephrite type (5, pp. 203—208); from Hurry Inlet he described an alnoitic rock (5, p. 208—214). All these rocks are much decomposed and their exact nature remains in doubt. It is clear that none of the Kap Dalton pebbles are identical with any of the rocks described by Backström or Nordenskjöld, but the hypabyssal rocks from among them are undoubtedly of closely related types. I would therefore suggest that the alkaline plutonic and hypabyssal rocks of Cape Parry, Cape Fletcher, Antarctic Harbour, etc. are the remnants of an igneous field which once included extensive alkaline lavas and that this is the source of the Kap Dalton conglomerate pebbles.

Nordenskjöld (5, p. 208) found in a conglomerate on Cape Brown which he considered Permian or Lower Triassic in age, pebbles of porphyries, etc., which he regarded as identical with some of the Cape Parry and Cape Fletcher igneous rocks. On this evidence he suggested a Palaeozoic age for the eruptives. Koch has confirmed the age of the conglomerate and has followed Nordenskjöld in the view that the igneous rocks of Cape Parry, Cape Fletcher, etc. are Palaeozoic, probably Hercynian in age (10, p. 124). As yet, however, no one has examined in detail the pebbles of the conglomerate and the similarity seems to be based on field observation only.

The discovery of highly alkaline plutonic rocks of Tertiary age in the Kangerdlugsuak area suggested to me in 1930 the possibility that the alkaline rocks from the region north of Scoresby Sound might also be late Cretaceous or Tertiary. The pebbles from Kap Dalton make this view still more likely. Noe-Nygaard has proved that some of the alkaline rocks about Davy Sound are intruded into the Upper Carboniferous or Lower Permian (20, p. 40); this still leaves a late Hercynian age as a possibility. Unfortunately there are apparently no convenient

late Mesozoic or Tertiary beds by which the age of the intrusive igneous rocks can be determined, and it may always be necessary to use indirect evidence such as is afforded by the magmatic similarity with the alkaline Tertiary rocks of Kangerdlugsuak or by the alkaline pebbles of the Eocene Conglomerate of Kap Dalton. Both of these lines of attack on the problem suggest strongly that the alkaline intrusive rocks about Davy Sound are of Late Cretaceous or Early Tertiary age.

If the hypothesis is accepted that the Kap Dalton pebbles are derived from a lava field, injected by hypabyssal and plutonic rocks, which once over-lay the region about Davy Sound, then we are driven again to the conclusion reached in discussing the derivation of the sediments of the Kap Dalton Eocene, namely, that the Jameson Land syncline and the uplift of the Liverpool Coast are, over Eocene happenings. The composition and sequence of the Kap Dalton Sediments, perhaps deposits on the southern side of a large Liverpool Land island, seem to reflect the uplift and uncovering of Liverpool Land from its postulated lavas. Some further evidence for such a lava cover seems to come from a study of the dissected peneplains from which the mountains of Liverpool Land seem to be cut (18). If the date of uplift is substantiated as Lower Eocene, a study of the development of the land-forms along the lines which I have already sketched out in a previous paper (19) should be of particular interest.

In 1918 Holmes described the basalts of the North Atlantic Tertiary Province (8) and pointed out that the later phases of this period of igneous activity, so far as the evidence available went, were the more alkaline. Such a generalization can no longer be accepted since this period in East Greenland evidently began with highly alkaline basalts.

By the recent discoveries at Kangerdlugsuak and Kap Dalton of a whole series of highly alkaline intrusive rocks and nepheline- and leucite-bearing lavas, the range of types occurring in the Tertiary North Atlantic Igneous Province is greatly extended.

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PLATES

Plate 1.

Fig. 1: Malignite (E. G. 1047, D) consisting of purple, pleochroic augite (altering patchily to dark brown hornblende), nepheline, orthoclase, iron ore, sphene and apatite with interstitial analcite. Magnification $\times 16$.

Fig. 2: Tinguaita (E. G. 1047, B) Phenocrysts of nepheline, orthoclase, decomposed nosean and aegerine, with rare sphene and apatite set in a ground mass, for the most part decomposed, but containing fresh aegerine needles and rare, fresh, plagioclase laths. Magnification $\times 16$.

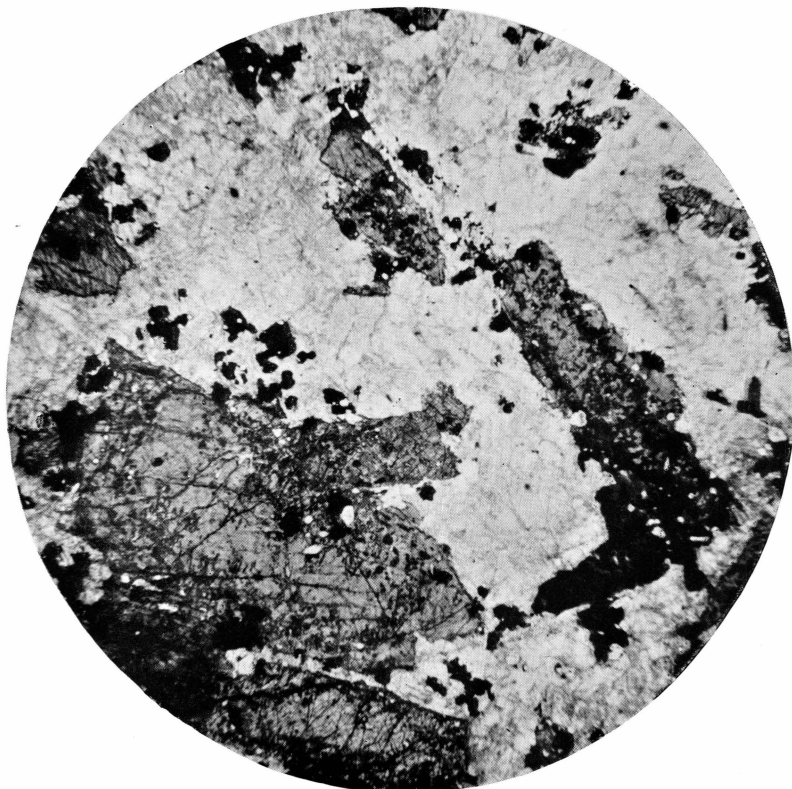


Fig. 1.

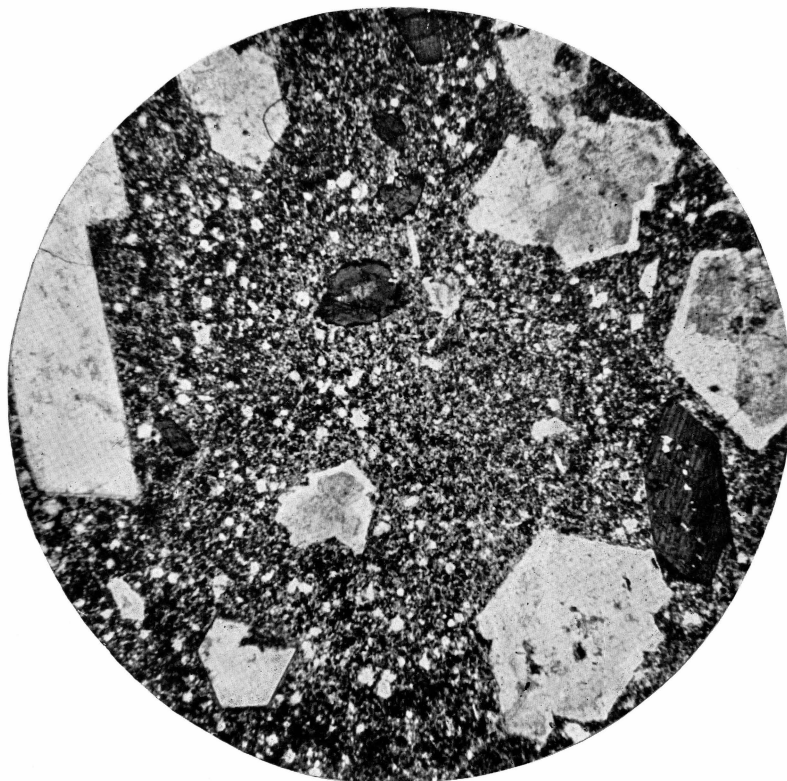


Fig. 2.

Plate 2.

Fig. 1: Tinguaita (E. G. 1047, J) Phenocrysts of purple augite, decomposed nepheline, brown hornblende (not seen in the photo-micrograph) iron ore, sphene and apatite in a ground mass consisting of acicular aegerine, brown hornblende, analcite and some feebly birefringent substance probably orthoclase. Magnification $\times 70$.

Fig. 2: Pyroxene-monchiquite (E. G. 1047, Q). Mainly purple augite (the larger crystals having green centres) set in an indeterminable, partly isotropic base. Magnification $\times 70$.

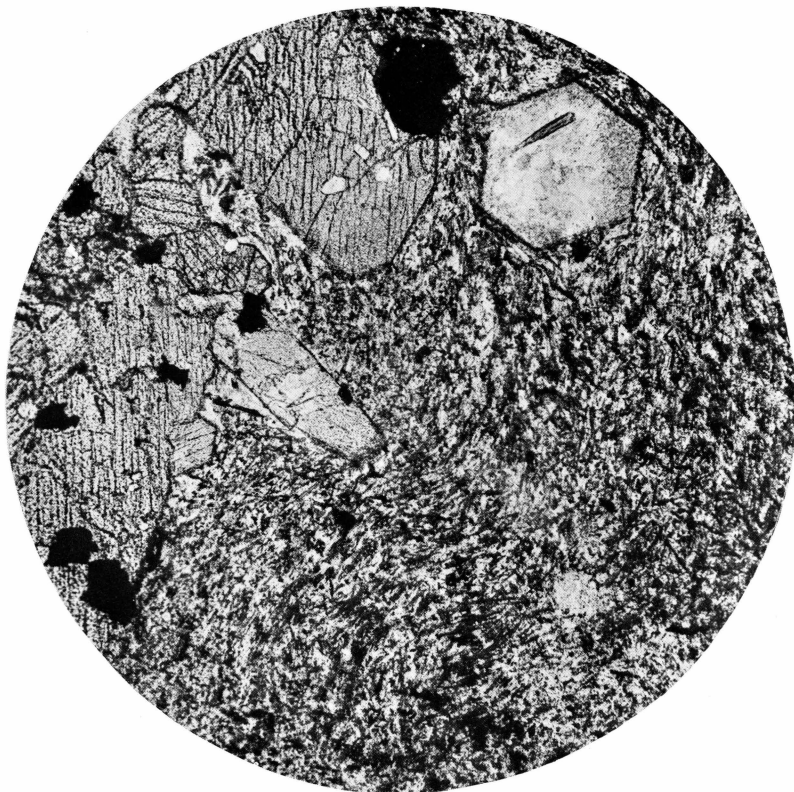


Fig. 1.



Fig. 2.

Plate 3.

Fig. 1: Pyroxene-monchiquite (E. G. 1047, P). Rare purplish phenocrysts of augite in a ground mass of stumpy purple augite crystals and iron ore surrounded by colourless material probably mainly analcite. Large irregular patches of analcite are uniformly distributed. Magnification $\times 70$.

Fig. 2: Hornblende-kersantite (E. G. 1047, I). Phenocrysts of oligoclase-andesine (partly replaced by epidote), iron ore and some ferromagnesian mineral (now chlorite) in a base of hornblende and felspar. Magnification $\times 70$.



Fig. 1.

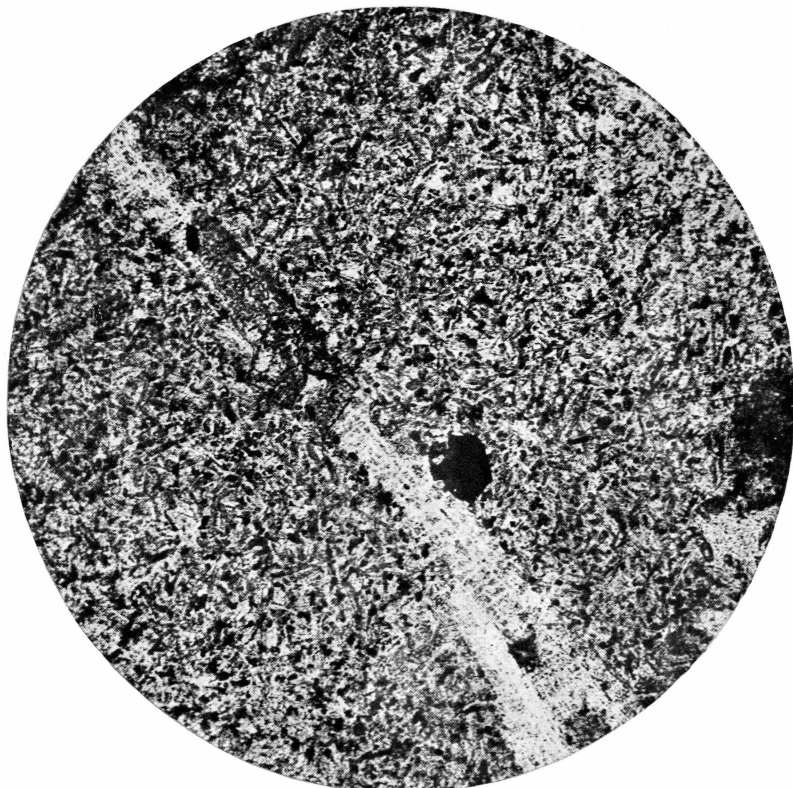


Fig. 2.

Plate 4.

Fig. 1: Soda-trachyte (E. G. 1047, C). Rare phenocrysts of oligoclase-andesine and iron ore (not seen in photo-micrograph) set in a base of felspar and iron ore. Magnification $\times 70$.

Fig. 2: Trachy-andesite (E. G. 1047, F). Phenocrysts of faintly pleochroic, purple augite and iron ore in a base of oligoclase-andesine, purplish augite and iron ore with occasional flakes of biotite and green hornblende. Magnification $\times 70$.



Fig. 1.



Fig. 2.

Plate 5.

Fig. 1: Trachy-basalt (E. G. 1047, E) cf. Dunsapie type. Phenocrysts of zoned greenish to purplish augite, andesine-labradorite and altered olivine surrounded by a ground mass of smaller plagioclase and augite crystals with less definite felspathic material and glass. Magnification $\times 70$.

Fig. 2: Analcite-rich trachy-basalt (E. G. 1047, G). Rare, large crystals of iron ore and apatite, crowded with iron ore granules, set in a base of felspar, greenish pyroxene and iron ore with frequent zeolitic patches, mainly analcite. Magnification $\times 70$.



Fig. 1.

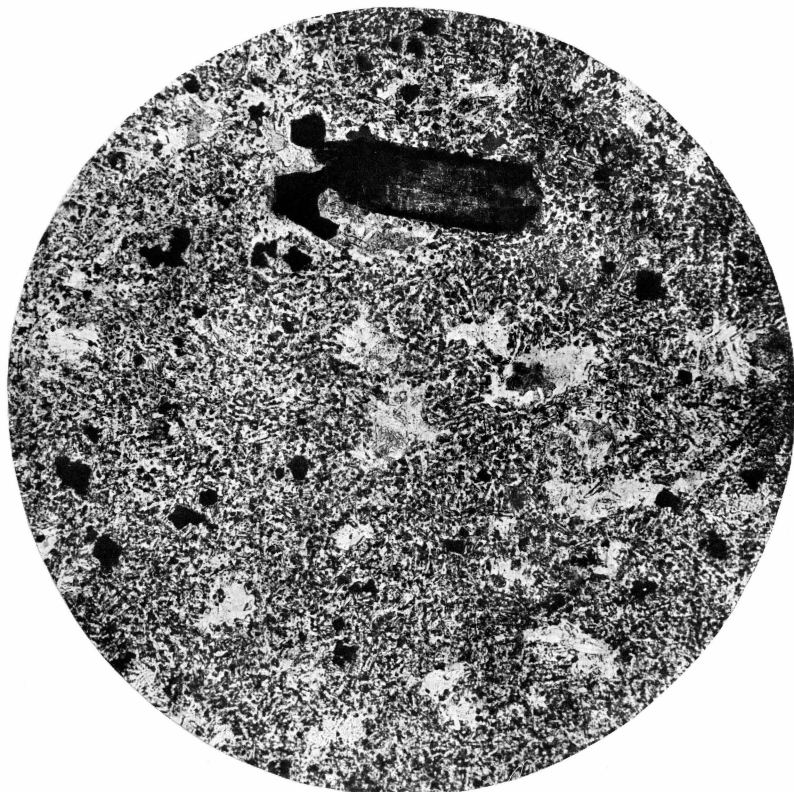


Fig. 2.

Plate 6.

Fig. 1: Leucite-nephelinite (E. G. 1047, A). Purple augite, iron ore, perovskite, nepheline and leucite set in a ground mass of acicular purple augite crystals and some colourless material probably mainly nepheline. Magnification $\times 70$.

Fig. 2: Nepheline-leucitite (E. G. 1047, M). Phenocrysts of decomposed nepheline and fresh aegerine-augite, bordered by aegerine, in a patchy base consisting largely of stumpy aegerine crystals and decomposed leucite. Magnification $\times 70$.

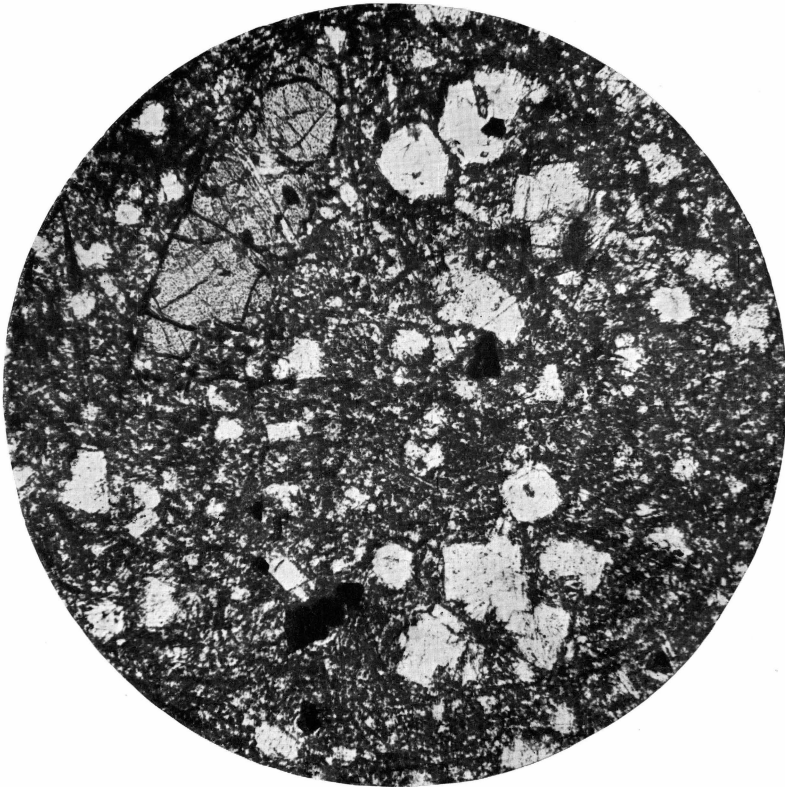


Fig. 1.

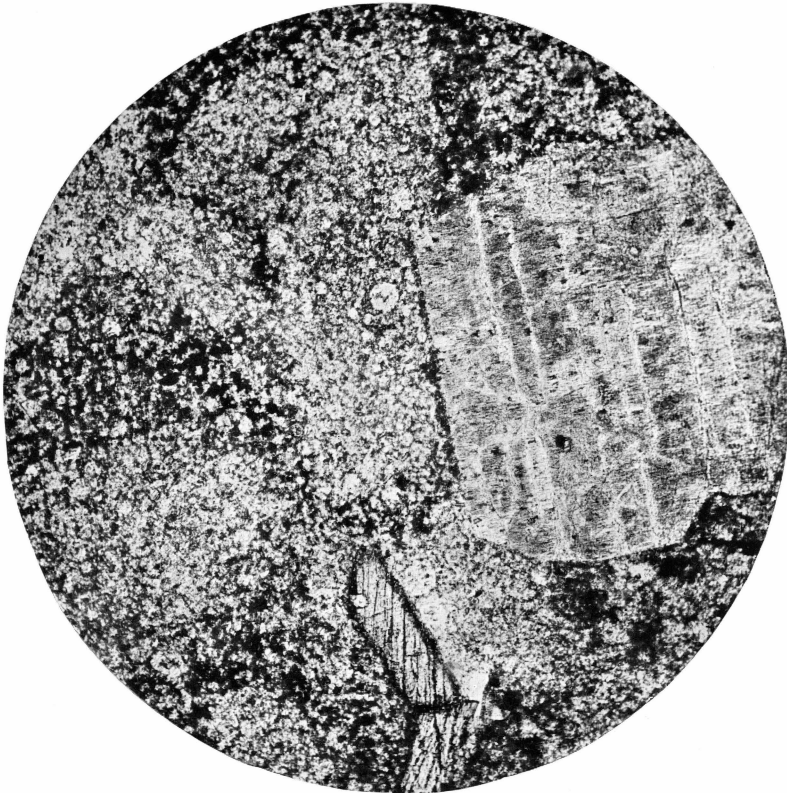


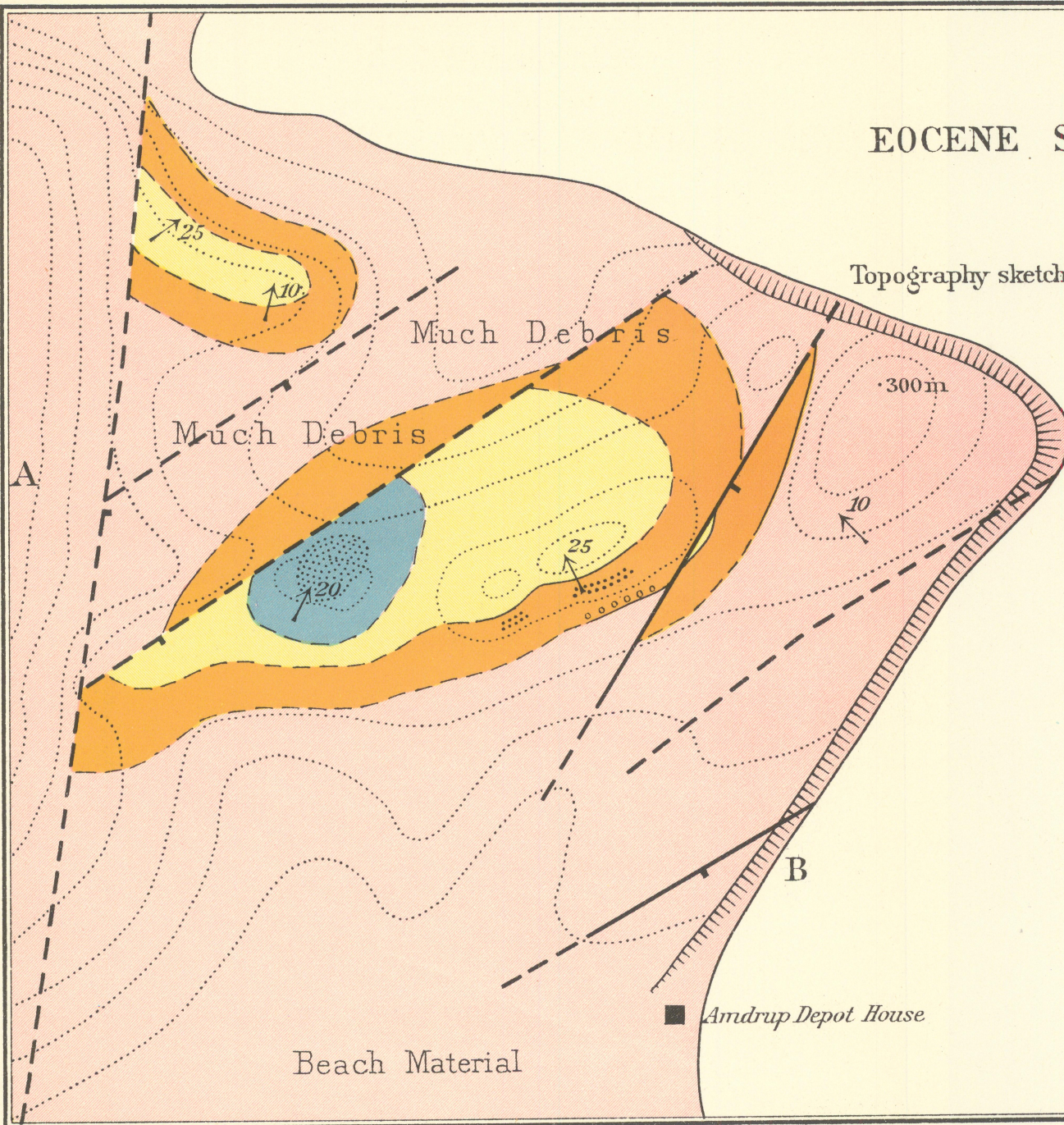
Fig. 2.

Plate 7.

Geological sketch-map of the Tertiary Sediments of Kap Dalton.

SKETCH MAP OF THE EOCENE SEDIMENTS OF KAP DALTON BY L.R. WAGER

Topography sketched on the basis of an unpublished map 1:200000 by
M. Spender and Chr. Larsson.



Legend

Vertical Scale
1 inch = 100 ft.

Upper Series	White Shales
	Coeloma Beds
Middle Series	Yellow Sandstone
	Black Sandstone Brown Sandstone
Lower Series	Cyrena Beds
	Conglomerate
Plateau Basalts	
Boundaries	Undefined
	Defined
Faults	Undefined
	Defined
	Form Lines

Scale ca. 1:17000
Miles

