THE IGNEOUS GEOLOGY OF THE DALMENY DISTRICT.

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TOPOGRAPHY. The extent of the area dealt with in this thesis and the position in that area of the various igneous masses under consideration are indicated in the sketch-map appended. On both sides of the Firth of Forth the ground considered consists of low lying, undulating, arable land intersected by numerous steep ridges. These ridges, which form conspicuous features in the landscape, indicate the outcrops of doleritic sills. They are often tree-clad and frequently show lines of cliffs on one side. The ridge known as Mons Hill attains a height of 387 ft. which is the maximum for the district. Other conspicuous ridges occur at Craigie, Dundas, West Craigs, Lindsay's Craigs, and north of the Forth at Braefoot and Aberdour. Where the larger igneous masses reach the shore they tend to form rocky promontories as for instance at Hound Pt, Snab Pt, and Braefoot. Rocky islets a short distance off shore may also be formed, a good example of which is seen at Hound Pt.

Except on parts of the ridges of igneous rock the country is thickly covered with boulder clay and numerous/

numerous large erratics are to be seen where the ground is not under cultivation. At the west edge of the road-metal quarry at Dickson's Craigs the thin covering of boulder clay has been removed from the underlying teschenite and beautiful ice-moulding of the igneous rock is now exposed. The striae run almost due E. and W. (See Plate 2 Fig 3)

The southern portion of the district is drained by the R. Almond which reaches the Firth of Forth at Cramond Village. This river has cut a gorge through the quartz dolerite sill of West Craigs between Cramond Brig and Craigiehall. In pre-glacial times the R. Almond reached the Forth near Dalmeny House after flowing between the sills of Craigie and West Craigs.(1) No other stream of importance occurs in the district, but a well-marked pre-glacial valley occurs in the heart of the Hound Pt. quartz dolerite sill between Castle Craig and New England. This deep and steep-sided valley is entirely dry and practically free from boulder-clay, quartz dolerite being exposed even along the bottom. It seems probable that the valley became filled with boulder-clay during the glacial period, but that it acted as an overflow channel on the/

(1) H.M. Cadell. Trans. Edin. Geol. Soc. vol. 8 p. 194

the recession of the ice and the boulder clay was thus removed.

Traces of both the 25 ft. and the 100 ft. raised beaches are clearly visible on either side of the Forth.

Artificial exposures of igneous rock in the shape of road and railway cuttings, and quarries are abundant, helping to lighten the work of the investigator. While many of the quarries are disused, several of the larger ones are being worked for road metal at the present time, and from these very fresh material may be frequently obtained.

TYPES OF IGNEOUS ROCK. Seven types of igneous rock occur in the district and are enumerated below in order of abundance.

(1) Teschenite.
(2) Quartz-dolerite.
(3) Dalmeny basalt.
(4) Analcite dolerite.
(5) Analcite basalt.
(6) Dolerite without quartz or olivine.
(7) Theralite.

Each of the three last-named types occurs at one locality/

locality only.

(1) Large sills of teschenite occur at Mons Hill, Craigie, Dundas, Port Edgar, and Braefoot. Smaller sills occur at several localities in the immediate neighbourhood of Cramond Village, the Forth Bridge, and west of Kirkliston.

(2) Large sills of quartz-dolerite run inland from Snab Point and Hound Pt., reaching West Craigs and Mansion Hill respectively, while a smaller sill may be traced inland from Eagle Rock for about ½ mile.

(3) Dalmeny basalt occurs at three localities. The most important of these is the village of Dalmeny where a lava flow provides the type rock. Another flow is exposed on both sides of Barnhill Bay near Aberdour. The Buchans are made up of Dalmeny basalt and probably represent a lava flow as the rock is highly vesicular.

(4) A large sill of analcite dolerite surrounds the village of Aberdour running from Braefoot to Hallcraig, and the teschenite of Dundas appears to have a marginal facies of analcite dolerite.

A/

A small sill near Cramond Village is probably analcite dolerite, but the rock is much decomposed.

(5) Analcite basalt occurs as a small sill in Dalgety Bay.

(6) The third intrusion (on the shore) east of the R. Almond is a small dolerite sill without quartz or olivine.

(7) Theralite occurs as a marginal facies on both sides of the Mons Hill Sill at Whitehouse Point.

PYROCLASTIC ROCKS. A bedded ash containing fragments of basalt, limestone, oil-shale, and quartzite occurs on the west side of Mansion Hill, while another similar ash crosses the L. & N.E.R. North West of Dalmeny Village. An ash neck occurs ½ mile W. of Dalmeny Village.

SEDIMENTARY ROCKS. The sediments of the district consist mainly of white sandstones with occasional bands of limestone, shale, black sandstone, ironstone, marls and blaes. The Port Edgar and Barracks ashes are not dealt with in this thesis.

HISTORY OF INVESTIGATION.

As an admirable summary of the literature of the igneous rocks near Edinburgh has been given by Dr Flett in the Geol. Surv. Memoir of the district, the writer will content himself with drawing attention to a very few papers.

In 1879 Sir Archibald Geikie described in his paper on "The Carboniferous Volcanic Rocks of the Basin of the Firth of Forth" the rock of Crossall Hill giving a very good figure. He laid particular stress on the curious habit of the ilmenite.(1)

Nine years later Dr Stecher gave an account of "Contact Phenomena of some Scottish Olivine-Diabases" choosing as three of his examples the rocks of Hound Point, Hawk Craig (Hall Craig), and Newhalls.(2)

In the same year Sir J.J.H. Teall recorded the occurrence of quartz-hypersthene dolerite at Ratho. He also recognised the teschenitic affinities of the rocks of Carcraig and Necropolis Hill, thus making one of the greatest advances in Scottish Petrology.(3)

Between 1888 and the publication of the Edinburgh Memoir in 1910 the igneous rocks of the district under consideration did not receive special consideration in any/

(1) Trans. Roy. Soc. Edin. Vol. 29. p. 489.
(2) Proc. Roy. Soc. Edin. No.127, p.160.
(3) British Petrography 1888, p.292.

190-1.

any paper but numerous similar rocks were described from other localities in the Midland Valley of Scotland.

In the Edinburgh Memoir Dr Flett has given a very complete account of the petrology of the igneous rocks of the district.

Fresh light was thrown on the stratigraphy of the Dalmeny District by the publication of the Oil Shales Memoir in 1912[1] but since that date no advances have been made.

FIELD RELATIONS.

HORIZON. It is fairly safe to state that all the igneous and pyroclastic rocks under consideration south of the Firth of Forth lie within the Oil Shale group of the Calciferous Sandstone series. In all probability the Craigleith Sandstone and Grey Shale are respectively the lower and upper limits.

North of the Firth of Forth the horizon of the rocks/

(1) "Oil-Shales of the Lothians" 2nd edition, p. 72.

rocks dealt with is a matter of some doubt. It seems clear that they lie within the Calciferous Sandstone series but their exact position is not known. They certainly lie well below the Mungle Shell Bed of St David's which is the nearest known horizon. When the researches of Dr C.A. Matley are published, the stratigraphy of the Aberdour district will doubtless be cleared up.

FLEXURES AND FAULTS. Towards the close of the Carboniferous period our district was affected by a series of flexures whose axes ran N. and S. The principal of these is known as the Kirkliston Arch, whose axis runs north from Kirkliston to Port Edgar. To the east of this large anticline lies the corresponding syncline known as the Queensferry Trough. The Aberdour rocks are folded into a well-marked anticline whose axis runs N. and S. through Porthaven.

After the formation of these folds the district underwent further disturbance and a series of great faults were formed running, for the most part, E. and W. The most important of these is the Ochiltree Fault which bisects the southern portion/

portion of the district. It runs approximately E. and W. and branches at Dalmeny where it has a downthrow to the S. of about 1,000 ft. Another great E. and W. fault to the north of Aberdour has a downthrow to the north and truncates the analcite dolerite sill of Hallcraig.

RELATIVE AGE OF TESCHENITES AND QUARTZ DOLERITES.

The quartz dolerite dykes of the Midland Valley have been shown to cut the teschenite sills in more than one locality, and it has also been observed that the sills and the dykes of quartz dolerite are often intimately related to one another, and are probably never far removed in age. It is believed that the teschenite sills of the Edinburgh district were intruded before the formation of the flexures mentioned above, and represented the underground manifestation of the volcanic activity which was so widespread at the beginning of Carboniferous times. The similarity in chemical composition of some of the lavas and the teschenites is brought out by the analyses quoted below:-

TABLE./

	(1)	(2)
SiO_2	46.06	46.71
TiO_2	2.56	2.40
Al_2O_3	15.94	15.59
Fe_2O_3	2.94	8.27
FeO	7.44	1.40
MnO	0.31	0.18
MgO	4.14	4.90
CaO	7.04	6.41
SrO	not found	0.06
BaO	0.10	0.08
K_2O	2.76	2.85
Na_2O	4.95	4.97
H_2O (105)	.55	1.08
H_2O (above 105)	4.22	3.16
P_2O_5	0.84	0.76
CO_2	0.11	1.06
FeS_2	0.36	-
Total	100.32	99.88

(1) Teschenite (shore at Whitehouse Point, Dalmeny). (Analyst, Mr E.G. Radley).

(2) Kulaite (Blaikie's Heugh, E. Lothian). (Analyst, Mr W. Pollard).

The correspondence throughout these analyses is very close.

The quartz dolerite sills are thought to belong to a later phase of igneous activity. They are affected by the great E. W. faults, but appear to have been intruded after the folding of the district. Mr R. G. Carruthers considers them to be contemporaneous with the E. and W. faulting.(1) They change their position much more rapidly than do the teschenites.

FIELD RELATIONS OF TESCHENITE SILLS.

The field relations of the various teschenite sills of our district will now be considered, each sill being treated separately. It should, however, be mentioned at this point that the evidence points to the sills of Mons Hill and Port Edgar forming one and the same intrusion. There is also the possibility that the sills of Dundas and Craigie are related with equal intimacy.

CRAMOND VILLAGE SILLS.

Two thin sills of teschenite occur near Cramond Village. One of them is exposed on both sides of the/

(1) 'Oil-Shales of the Lothians'. 2nd edition, p.15.

the R. Almond near the ferry at Cramond Village. A junction with white sandstones dipping to the west is seen.

The other sill, which is somewhat thicker, is exposed on the shore about ¼ mile E. of Cramond Village where it forms a rocky ridge. No junction with sediments is seen but white sandstones dipping to the west at 40° are seen at a few yards distance on either side.

The horizon of both these sills is doubtful but they must be well below the Burdiehouse Limestone.

MONS HILL AND PORT EDGAR SILL.

This great teschenite sill forms the upstanding ridge of Mons Hill and reaches the shore at Whitehouse Point. It is here seen to pass below shales which dip to the west at about 15°. These shales have been highly altered by the igneous rock and are now in the condition of spotted hornfelses. The actual junction is only exposed by exceptionally low tides and is masked by seaweed and mud. The position of the sill at Whitehouse Point is approximately 1000 ft. below the Burdiehouse Limestone and it has probably a thickness of over 500 ft. The lower junction is not exposed. Besides the excellent exposures at Whitehouse/

Whitehouse Point there are a number of disused quarries on Mons Hill and the rock forms an escarpment along the summit of the ridge.

At Port Edgar the sill appears at the crest of the Kirkliston Arch and again the bottom is not seen. There are good exposures along the highroad behind the naval base and also on the shore, but no junction is visible. Inland there is a large quarry near Lawflat from which fresh material may be obtained. The horizon of the sill at Port Edgar is below the Burdiehouse Limestone, but is higher than at Whitehouse Point.

CRAIGIE SILL.

The thick teschenite of Craigie forms the conspicuous tree-clad ridge which runs from Dolphington House to Clove Craig. At Clove Craig the ridge sinks into the alluvial plain of the R. Almond and the outcrop swings round from N.S. to E.W. with change of dip from W. to N. After forming the cliffs of Craigbrae the sill finally dies out to the west of these. The horizon of the sill is just above the Dunnet shale which is exposed in a baked condition in a/

a quarry near Craigie Farm. Exposures along the summit of the ridge are good, but fresher material may be obtained from the large road-metal quarry at Dolphington House, the road cutting at Clove Craig; and the railway cutting of the Dalmeny-Kirkliston branch. North of Carlowrie the presence of this sill over a large area has been proved by bores.

DUNDAS SILL.

The important teschenite sill of Dundas has a U-shaped outcrop, the bottom of the U facing north and lying about 1½ miles south of Port Edgar. The shape of the outcrop is due to the Kirkliston Arch. The outcrop measures close on 2 miles from end to end and forms a conspicuous topographical feature throughout its length, being thickly wooded and elevated above the surrounding country. Although the exposures are good and frequent, fresh material may only be obtained from one locality - a road-metal quarry at Carmelhill (1½ miles W. N.W. of Kirkliston). Elsewhere the rock is deeply weathered. The horizon of the sill is known to be within the Binny Sandstone.

LINDSAY'S CRAIGS SILLS.

This group of four small teschenite sills lies between Kirkliston and Overton. Three are inconspicuous and ill-exposed but the fourth forms the well-marked ridge running east from Overton and known as Lindsay's Craigs. An old quarry occurs in the centre of this ridge and there the junction of the teschenite with the overlying oil shales is admirably exposed. The igneous rock is seen to be altered to white trap to a depth of over a foot, but further down, quite fresh material may be collected. The exact position of this group of sills in the sequence is uncertain, but they probably lie near the Broxburn Shale.

All the above rocks are fairly coarse in grain and some of the thicker sills may be classed as 'very coarse' in their central portions. The remaining teschenite sill (that of Aberdour) is on the other hand comparatively fine in grain and in places has the appearance of a basalt.

ABERDOUR (OBELISK HILL) SILL.

Two thick sills running from Braefoot to Aberdour harbour/

harbour form semicircles surrounding the village of Aberdour. The inner sill is of teschenitic composition and will be referred to below as Braefoot 2. The outcrop of Braefoot 2 is indicated by a more or less continuous ridge but good exposures are only to be found on the shore at Braefoot and at Obelisk Hill above Aberdour village. At Braefoot the rock weathers to a bright reddish-brown colour like the teschenite of Salisbury Crags. A fine junction with shales is exposed in Aberdour harbour. Unfortunately the horizon of Braefoot 2 is not known even approximately.

FIELD RELATIONS OF QUARTZ DOLERITES.

WEST CRAIGS SILL. The quartz dolerite sill of West Craigs is one of the largest in the Edinburgh district, and extends from Snab Point ~~on~~ to North Gyle. It forms a fairly well marked feature which is broken by the gorge of the R. Almond above Cramond Brig. Good exposures occur at Snab Point, the Almond Gorge, and in the large quarries near Lennie Park. A junction with shales is exposed in the R. Almond. The horizon of the sill has been fixed by the discovery/

discovery of the Pumpherston Shell Bed a short distance below it in the R. Almond.(1)

HOUND POINT SILL.

The Hound Point sill extends from Hound Point to the Ochiltree Fault by which it is truncated. The quartz dolerite outcrops between the two branches of the fault at Mansion Hill and Dunter Hill probably belong to the Hound Point Sill. Exposures are everywhere good and numerous small quarries exist along the outcrop. Junctions with shales and white sandstones are exposed at Hound Point and Quaker's Quarry. The junction at Hound Point has been frequently described. The exact horizon of the sill is doubtful.

EAGLE ROCK SILL.

A thin sill of quartz dolerite forms the promontory of Eagle Rock where it is well exposed. No junction is seen and the horizon is not known.

DALMENY./

(1) 'Oil-Shales of the Lothians'. 2nd edition, p. 77.

FIELD RELATIONS OF DALMENY BASALTS.

DALMENY. The type flow of Dalmeny basalt runs through the east end of Dalmeny Village and is exposed in two small quarries to the N. and S. of the road. No junction with sediments is seen, but the rock is highly vesicular. The horizon of this flow is between the Fells Shale and the Broxburn Shales.

BUCHANS. The group of rocks known as the Buchans consists of Dalmeny Basalt which is very vesicular, and the group probably represents a lava flow. It is, perhaps, significant to note that these basalts are on the same ~~strata~~ strike as the Dalmeny basalts W. of Inchcolm and on the shore at Porthaven. It is quite possible that all three occurrences belong to the same flow. They are, at any rate, petrologically identical. The Porthaven basalt is overlain by basaltic tuff. The horizon of these three occurrences of Dalmeny basalt is not known.

ABERDOUR/

FIELD RELATIONS OF ANALCITE DOLERITE.

ABERDOUR SILL. The outer of the two semicircular sills surrounding Aberdour is an analcite-dolerite. Good exposures occur at Braefoot and Hallcraig and at the latter point a good junction with shales and sandstones is seen and has been described by Dr E. Stecher. The inland exposures are practically non-existent, but a large quarry at Hallcraig provides material from the heart of the intrusion which must be at least 200 feet thick. Its horizon is not known.

CRAMOND SILL. The small dolerite sill on the shore 300 yards east of Cramond Village is probably a decomposed analcite dolerite. It is intruded into black shales and has been partially converted into white trap. A fine junction is seen with the shales which dip to the west at 40°. The horizon of this sill is not known.

FIELD RELATIONS OF ANALCITE BASALT.

DALGETY BAY SILL. A thin sill of analcite basalt occurs at Dalgety Bay. The junctions are not visible but westerly dipping sandstones are exposed on the shore/

shore at either side at a short distance. The horizon of this sill is not known but it is the highest of the Braefoot and Aberdour series.

FIELD RELATIONS OF OPHITIC DOLERITE.

CRAMOND SILL. A thin sill of ophitic dolerite without quartz or olivine occurs on the shore about 1000 yards east of Cramond Village. It shows a fine junction with white sandstones which are altered to a tough quartzite and dip to the west at 45°. The horizon of this sill is not known but it must be in the neighbourhood of the Craigleith Sandstones. (See Plate 2 Fig 1)

THE RELATIONSHIP OF THE MONS HILL TESCHENITE TOWARDS THE HOUND POINT QUARTZ DOLERITE.

While investigating the petrography of the Mons Hill sill the writer discovered some new points which are not recorded on the Geological Survey Map 6 in. = 1 mile (Linlithgowshire Sheet III S.W.). These points are outlined below.-

(1)/

(1) The Hound Point Sill does not die out at Earl Cairnie's Mound as mapped, but continues inland to the Ochiltree Fault by which it is truncated. The western boundary of the quartz dolerite passes west of Castle Craig and continues from there to Shepherd's Bog, while the eastern boundary runs from Earl Cairnie's Mound to New England and from there to Chapel Coppice. Thus a great part of what is mapped as teschenite is in reality quartz dolerite.

(2) That the south branch of the Ochiltree Fault runs further north than is mapped and passes a very short distance south of the old quarry at the east end of Mansion Hill Wood.

(3) That the Dickson's Craig Teschenite is probably to be correlated with the Mon's Hill sill and does not stretch as far ~~west~~ east as Mansion Hill. It is seen to have a northerly dip at Dickson's Craig and a southerly dip at Dunter Hill where it is not truncated by the north branch of the Ochiltree Fault but overlies a series of white sandstones dipping to the south at a low angle. The teschenite is truncated at its east end by a/

a cross fault which runs S.E. from the north branch of the Ochiltree Fault at Dunter Hill to south branch of the Ochiltree Fault at Mansion Hill. This cross fault has a downthrow to the north.

(4) That a small portion of the top of the Hound Point Sill appears in Shepherd's Bog, being faulted off by the north branch of the Ochiltree Fault. This quartz dolerite is overlain by black sandstones which have converted it to white trap to a certain extent.

(5) That about 75 feet of coarse bedded basaltic tuff lie against the cross fault on its downthrow side and form the lowest member of a sedimentary series, which lies in a syncline (whose axis runs S.E. and N.W.) between the two branches of the Ochiltree Fault.

(6) That this sedimentary series has been invaded, probably after folding, by a sheet of quartz dolerite which dips S.W. and caps the feature of Mansion Hill which is made up mainly of the basaltic tuff. This quartz dolerite which may be/

be correlated with that of Hound Point is seen to overlie fossiliferous shales and black sandstones in Quaker's Quarry. These black sandstones probably correspond to the series seen at Dunter Hill.

(7) That the group of rocks known as the Buchans consist, not as mapped, of quartz dolerite but of Dalmeny basalt.

(8) That the thin sill of white trap seen at Newhalls is not, as mapped, a teschenite but is a quartz dolerite. This may be seen by its inland extension in a railway cutting at Dalmeny where it proved to be very fine aphanitic quartz dolerite.

The evidence for the presence of the above mentioned cross fault is provided by the frequent and intense shattering of the bedded ash and by a distinct topographical feature. An abnormally high dip of certain white sandstones in the quarry at the west edge of Mansion Hill Wood is explained by their proximity to the south branch of the Ochiltree Fault.

The bedded ash was found to contain an enormous number/

number of basalt fragments which appeared to be all of the Dalmeny type. A few limestone fragments were found at Mansion Hill, and were all of a pure compact white weathering type resembling the cementstones in appearance. One or two fragments of oil-shale and quartzite were also found, while plant remains proved to be very common. The ash is of dark green colour and is quite unlike the ash found in the railway cutting at Dalmeny. This latter ash which occurs between the two leaves of Houston Coal is yellow and consists mainly of sedimentary material.

The extent of the above alterations is clearly seen by comparison of the two small-scale maps appended.

When mapping the Mons Hill and Hound Point sills it was found necessary to discriminate between teschenite and quartz dolerite in the field. This is not always an easy matter but the following criteria usually enable one to arrive at a decision.

(a) The escarpments formed by quartz dolerite sills differ in appearance from those of teschenite sills. The columns of quartz dolerite are seldom seen with sharp edges and there is very often spheroidal weathering. Teschenite, on the other hand, is nearly always seen in sharp edged columns and spheroidal weathering is very rare./

rare. The earth produced by the weathering of a quartz dolerite sill is of a much warmer brown than that from a teschenite sill.

(b) Biotite is usually visible in hand specimens of teschenite, but is hardly ever seen in quartz dolerites.

(c) Teschenites, in the hand specimen, generally have a more leucocratic appearance than quartz dolerites and the ferromagnesian minerals are usually fresher.

(d) Teschenites are frequently drusy but druses are never seen in quartz dolerites.

(e) Fine grained quartz dolerites have a blue tinge which is never seen in teschenites.

CLASSIFICATION OF TESCHENITES.

After investigating the teschenites of his own district and comparing them with teschenites from other parts of the Midland Valley of Scotland, the writer came to the conclusion that a fresh classification was desirable. A suggested classification of Scottish teschenites is therefore given below together with a very brief summary of previous classifications and observations based on a comparison with a few Moravian types.

EARLIER CLASSIFICATIONS.

The name 'teschenite' was first used by Hohenegger, who applied it in a very general sense to certain igneous masses intrusive into Cretaceous strata in the neighbourhood of Teschen in Moravia.(1)

In 1866 Tschermak separated from Hohenegger's teschenites the more basaltic looking occurrences to which he gave the name 'picrite' on account of their high magnesia content (due to abundant olivine). The name 'teschenite' was thus restricted to the more leucocratic/

(1) Hohenegger, L. "Geognostische Verhältnisse der Nord-Karpathien". 1861.

leucocratic varieties. Tschermak was also the first to recognise that analcite was an important constituent of teschenite, forming up to 27% of the rock. He distinguished between hornblende and augite teschenites, thus making the first serious attempt at a classification.(1)

The next great advance was made by Rohrbach in 1885, but during the intervening years the great controversy over the presence of nepheline and the origin of the analcite in teschenites had arisen, nepheline-bearing teschenites from Moravia and the Caucasus being described by Rosenbusch and Tschermak. Rosenbusch held that the analcite in teschenites was secondary, replacing nepheline - a view which he maintained throughout his later writings. Rohrbach investigated the teschenites of both Moravia and the Caucasus, but was unable to find any nepheline, even by microchemical tests. He considered that the analcite arose through decomposition of the plagioclase which it frequently replaced. He divided the teschenites primarily into two groups, (1) ophitic, and (2) non-ophitic. The latter group was further divided into several sub-groups on textural and mineralogical grounds. Hornblende was a variable but ubiquitous /

(1) Tschermak, G. Sitzungber. d. k. Akad. d. Wissensch. in Wien. 53. I. p.260-287.

ubiquitous constituent of the second group, but was absent from the ophitic or diabasic group.(1) Rosenbusch recognised the value of this exceedingly careful research, but remained unconvinced that the analcite originated from plagioclase. In his last (1907) edition of Mikroscopische Physiographie, II, p.431, he expresses his conviction that the teschenites are to be reckoned as altered theralites.

Teall was the first to recognise teschenitic intrusions in the Midland Valley of Scotland, and since his description of the Carcraig rock in 1888, numerous fresh occurrences of this type have been investigated.

In recent years the work of Bailey, Campbell, Tyrrell and others has adequately demonstrated the primary nature of most of the analcite in teschenites. It has also been observed that when nepheline occurs in teschenite it does not alter into analcite. To quote Tyrrell:-(2) "Nepheline does occur in some teschenites and is often altered; but it does not alter into analcite. Analcite has been shown to be a primary constituent of teschenite, and many other analcitic rocks; but owing to its aqueous constitution, and the consequent mobility and chemical activity/

(1) Tschermak's Min. und Pet. Mittheilungen VII. 1885, p. 1-63.

(2) Geol. Mag. November 1921, p.501.

activity of its solutions or magma, it is an extremely efficient agent of paulopost alteration in previously formed mineral constituents, with the result that the analcite itself has been regarded as secondary.
In other words the analcite is not due to the alteration of the other minerals but the alteration is due to the analcite."

To Tyrrell (1) we owe the classification of the West of Scotland teschenites into three groups.-

(1) Glasgow type

(2) Galston Type

(3) Cathcart type with nepheline.

Some of the East of Scotland teschenites have, however, no place in this classification, notably the rock of Spalefield near Anstruther.

DEFINITIONS OF TESCHENITE.

It is essential to have clear and comprehensive definitions of rock-types before attempting their classification. Modern petrological treatises are unkind to the teschenities in this respect, and the writer has not yet found two authors who give the same definition.

(1) Geol. Mag. Dec. 1912, p.74.

Hatch gives the following simple definition:-(1)

"The teschenites or analcite dolerites are dyke rocks essentially composed of plagioclase felspar, augite, and analcite. Olivine is also a frequent constituent".

The objections to this definition are first, the inclusion of the analcite dolerites under the name teschenite, and second, the absence of any mention of amphibole as a frequent constituent. The vast majority of rocks described as analcite dolerite have a much lower alkali percentage than teschenites and are more closely related to the olivine dolerites.

According to Iddings,(2) "Teschenites are analcite theralites composed of lime-soda felspar, analcite, augite, barkevikitic amphibole, and some biotite and apatite. The analcite may be altered nepheline. The texture is medium grained equigranular".

When discussing theralites Iddings points out that many rocks which have been described as teschenites are, in reality, altered theralites. Thus Iddings inclines towards the view of Rosenbusch that the analcite is derived from the decomposition of nepheline - a view which is now discredited by the majority of petrologists./

(1) "The Petrology of the Igneous Rocks" 7th Ed. 1914, p.234.
(2) "Igneous Rocks" vol.II, 1913, p.248.

petrologists. A decided objection to the above definition is that the presence of barkevikite is considered essential.

Holmes defines a teschenite as:- (1) "An alkali-rich variety of analcite dolerite characterised by the presence of idiomorphic purple augite, or aegirine-augite, and generally containing soda-amphiboles such as barkevikite".

The only important objection to this definition is the use of the words idiomorphic purple augite, for in a great many teschenites the augite, far from being idiomorphic, is strongly ophitic. Moreover, as Tyrrell points out, the term dolerite should always connote ophitic texture.

Harker (2) does not define the term teschenite, but includes the teschenites in the gabbro group commenting upon the difficulty of drawing a line between the teschenites and the theralites.

As there are a great many textural varieties of teschenite, the ideal definition would seem to be one on a mineralogical basis only. The writer suggests the following definition as an improvement on any of the foregoing.

"Teschenites are rocks consisting essentially of plagioclase/

(1) "The Nomenclature of Petrology," 1920, p.234.

(2) "Petrology for Students" 5th ed. 1919. p.82.

plagioclase felspar (which is partially or wholly analcitised), titan augite, and analcite. Barkevikite is often present, sometimes reaching a greater abundance than the titan augite, and olivine is a frequent constituent". Accessory minerals may include nepheline, zeolites, alkali felspar, aegirine augite, biotite, apatite, ilmenite, and pyrites.

This definition has the advantage of drawing a sharp line between the analcite dolerites (including the Crinan type)(1) and the teschenites, without the introduction of any arbitrary condition. Analcite in certain analcite dolerites may be observed filling cracks in the larger plagioclases, but the patchy replacement of plagioclase, so characteristic of teschenites, is never seen.

RELATIONSHIP OF TESCHENITES TO THERALITES AND CAMPTONITES.

With increase of nepheline and decrease in the quantity of analcite, the teschenites grade into the theralites for which Lacroix has recently produced a classification.(2) The nepheline teschenites of Cathcart and Lugar are half-way houses between the two/

(1) "The Geology of Colonsay" Mem. Geol. Sur. 1911, p.42. PLATE I, FIG 4

(2) Comptes Rendus. CLXX, 1920, p.20-25.

two types and may be classed either with the teschenites or with the luscladite or berondrite groups of the theralites.

With diminution of the amount of analcite the non-ophitic and sub-ophitic hornblende teschenites show a gradual passage into camptonites. Such camptonites are found in Iona, and as segregations in teschenite sills at Whitehouse Point, Inchcolm, and elsewhere. These segregations are of much finer grain than the normal rock, and usually show well-marked ocellar structure.

SUGGESTED CLASSIFICATION OF SCOTTISH TESCHENITES.

The following classification of the Scottish teschenites is suggested:-

A. Porphyritic or Basalt Type. (Plate I, Fig. 3)

Characterised by conspicuous phenocrysts of fresh olivine and two generations of titanaugite. The grain is fine to medium.

B. Ophitic or Dolerite Type. (Plate I, Fig. 1)

Typically non-porphyritic and characterised by well-marked ophitic or sub-ophitic relationship between the titanaugite and the plagioclase. The olivine is invariably serpentinised and the grain medium to coarse.

C. Non-ophitic or Gabbro Type. (Plate 1, Fig 2.)

Typically non-porphyritic and characterised by even-grained hypidiomorphic texture. In varieties rich in analcite both the titanaugite and barkevikite are euhedral. Ophitic structure is absent and the olivine invariably serpentinised. The grain is medium to coarse.

The above division of the teschenites into three groups has been made on textural grounds. Each of the primary groups may be further divided into two sub-groups:-

(1) Varieties with barkevikite.

(2) Varieties without barkevikite.

The distribution of the barkevikite is however so exceedingly capricious in some rocks that the value of this further division is doubtful. It is convenient to refer to teschenites containing barkevikite as hornblende teschenites, the term augite teschenite being reserved for varieties without barkevikite. A few examples follow of typical rocks in each division.

A. The rock of Spalefield, near Anstruther, may be taken as typical of this division. A detailed description/

description of this hornblende teschenite has been given by Dr Flett[1] and is therefore unnecessary here. The barkevikite is not abundant, but is a fairly constant constituent forming small idiomorphic prisms in the groundmass. Some of the titanaugite phenocrysts show a purple margin round a green centre - a reversal of the usual state of affairs.

Only one other Scottish teschenite known to the writer, may be placed in group A. This is the augite teschenite sill of Obelisk Hill and Braefoot whose petrology is described below.

Nepheline was not observed in either the Aberdour or the Spalefield rocks, and in this respect they differ from the nepheline teschenite of Cathcart which, if it is to be grouped with the teschenites at all, must come under this division. The Cathcart rock has, however, strong theralitic affinities. Olivine forms an abundant constituent of all the above rocks, but diminishes in amount in specimens belonging to the other two groups.

(1)"Geology of E. Fife". Mem. Geol. Sur. 1902, p.392.

B. This group includes a very large proportion of the Scottish teschenites. As an example of a true ophitic type the teschenite of Gullane Head may be taken for it is a well-known rock and has been carefully described by Prof. Young.(1) Hornblende occurs sporadically in this intrusion.

A very fresh example of a sub-ophitic type is afforded by the augite teschenite of Mons Hill. By this is meant the exposures on the eastern slopes of Mons Hill itself and not the rock of Crossall Hill or Whitehouse Point. The rock of Mons Hill is described below. The rock from the second intrusion east of the mouth of the R. Almond is a finer grained teschenite of similar type but is richer in analcite and contains some barkevikite in places, both in parallel growth with the titanaugite and as separate prisms. Group B. includes the majority of the rocks which come under the Glasgow and Galston types of Tyrrell.

C. The rocks of group C appear to be confined to the West of Scotland. The rock from the margin of the Mons/

(1) Trans. Edin. Geol. Soc. VIII. 1905, p.326.

Mons Hill Sill at Whitehouse Point approaches the necessary conditions closely, but contains too much nepheline to be reckoned as a teschenite. To obtain a true non-ophitic hornblende teschenite we must turn to the Lugar Sill which has been exhaustively described by Mr Tyrrell.(1) In this complex intrusion it is found that the rock named 'lugarite' fulfills the necessary conditions and may be regarded as a hornblende teschenite which is extremely rich in analcite. Nepheline is not an important constituent of the sections in the possession of the writer, and barkevikite is present in greater quantity than titanaugite. Pseudomorphs after olivine are rare or absent.

The teschenite sill of Cranhill affords an excellent example of a non-ophitic augite teschenite. Euhedral prisms of titan augite showing well-marked hourglass structure are set in an aggregate of analcite and plagioclase. The plagioclase is largely analcitised. Green pseudomorphs after olivine are of frequent occurrence and minor constituents include alkali felspar, biotite, apatite, and ilmenite. The rock is very dark in colour in the hand specimen.

(1) Q.J.G.S. LXXII, 1917, p.107-109.

MORAVIAN TESCHENITES.

In order to make a comparison between the Scottish and Moravian teschenites ten sections of the latter were obtained. Five were loaned from the collection of the Sedgwick Museum in Cambridge through the kindness of Dr Harker, three were taken from a collection illustrating Rosenbusch's Mikroskopische Physiographie, while the remaining two were purchased from Voigt and Hochgesang. Two of these ten slides had unfortunately to be rejected as one from the Rosenbusch collection, labelled Neuitschein, was a monchiquite, and another purchased from Voigt and Hochgesang, labelled Söhla was a camptonite. Of the other eight sections five were coarse, markedly ophitic augite teschenites greatly resembling many of the coarser Scottish rocks and almost indistinguishable from the rock of the central portion of the Mons Hill sill at Whitehouse Point. Four were from Teschen and one from Boguschowitz. The remaining three sections were all non-ophitic. One from Teschen was an augite teschenite very similar to the Cranhill rock and showing the same euhedral augites with hour-glass structure. The second section (from Boguschowitz) showed an equally close resemblance to Tyrrell's lugarite, the euhedral barkevikites and titanaugites being set in a turbid aggregate of leucocratic minerals in the same fashion. In the Moravian rock, however/

however, the barkevikites are partially chloritised and the surrounding minerals stained green. The third and last section (from Pod Rudan) resembles the second but is fresher. The large euhedral barkevikites and titanaugites are unaltered, and the latter have a very pronounced green margin. The leucocratic minerals consist of analcite and other zeolites which often replace plagioclase and alkali felspar. A few small crystals of soda amphiboles and pyroxenes are present, and large brownish apatites are common. The rock has a certain resemblance to the analcite syenite of Howford Bridge but is richer in zeolites and barkevikite. These last three sections all fall into Rohrbach's non-ophitic group.

According to the writer's classification the five ophitic sections would all fall into group B. (doleritic), whilst the non-ophitic ones might be placed with equal confidence in group C of the non-ophitic gabbro-like teschenites.

It is interesting to note the close resemblance of the Moravian rocks to our Scottish types and to find lugarite represented in the former province. From the very limited material available it appears that the Scottish classification is applicable to the Moravian teschenites.

PETROGRAPHY OF TESCHENITES.

All the teschenites of the district belong to the ophitic group with the exception of the rock from Braefoot 2 which is a basaltic type. No rock of the third non-ophitic group is represented in this district. A description follows of the petrography of each sill.

MONS HILL SILL.

Almost the whole thickness of the Mons Hill Sill is exposed at Whitehouse Point only the lowest portion remaining invisible. The central portion of the sill consists of coarse ophitic augite teschenite. Above and below this, sharp junctions are seen with finer grained marginal modifications which themselves show many variations. Chilling of one modification against another is very seldom seen and the inference is drawn that the various modifications resulted through differentiation in situ. A description of the modifications from top to bottom of the sill will now be given.

The first modification met with is apparently the one described by Dr Flett in the Edinburgh Memoir.(1) It is of medium grain and dark in colour and shews small/

(1) "The Geology of the Neighbourhood of Edinburgh" Mem. Geol. Sur. p.297.
(See Plate I Fig 5)

small glittering needles of barkevikite in the hand specimen. Under the microscope it is seen to consist of elongated prisms of dark brown barkevikite and stouter prisms of purple titanaugite set in an aggregate of plagioclase, alkali felspar, analcite, nepheline, and iron ores. Biotite and apatite are abundant accessories. The barkevikite, which has the usual red-brown to straw-yellow pleochroism and an extinction angle of 12^{o}, is sometimes twinned and is occasionally seen in parallel growth with the titanaugite. It was one of the first minerals to crystallise and invariably shows pronounced idiomorphism. The purple titanaugite prisms usually show greenish margins. They too show strong idiomorphism. In most slides the barkevikite and titanaugite occur in equal abundance but either may preponderate. The biotite occurs as large flakes frequently penetrating analcite patches. Occasional serpentinous pseudomorphs after olivine may be seen but are rare. The plagioclase occurs as broad zonal tables and is frequently replaced by analcite; it ranges from a basic labradorite to oligoclase and is often surrounded by mantles of alkali felspar or nepheline. The nepheline is abundant and is allotriomorphic towards all other constituents/

constituents except analcite. It is only rarely seen fresh and is usually pseudomorphed by light brown decomposition products. When fresh it shows straight extinction, well marked cleavage, grey polarisation tints and negative elongation in the direction of the principal zone. It gelatinises on treatment with HCl and can then be stained by fuchsine or malachite green. It is associated with a yellow polarising decomposition product which has a higher refractive index and appears to be identical with the mineral described by Bailey and by Tyrrell.(1) The analcite occurs in large patches throughout the rock and may be clear or turbid. These patches enclose flakes of biotite and needles of apatite. The iron ores appear to be titaniferous magnetite and pyrites. In view of the abundance of nepheline it has been thought advisable to describe this rock as a theralite rather than a teschenite. It is typically non-ophitic. Three different types of segregation veins occur in this modification, of which two are black and one pink.

The first black type is merely a textural modification which is somewhat richer in ferromagnesian minerals and shows ocellar structure. The grain is fine. Taken by itself, this type of vein would be classed among the camptonites. The second black type/

(1) "The Geology of E. Lothian". Mem. Geol. Sur. 1913.

type resembles the first but contains, in addition, large phenocrysts of plagioclase and titanaugite. The titanaugite shows decomposition to biotite in places, and biotite is also abundant in the ground mass.

The pink type of vein is always much decomposed but appears to consist of biotite, alkali felspar, and analcite with the doubtful addition of nepheline. It is of medium grain and non-porphyritic. All three types are either contemporaneous or very little later than the theralite as no chilling is seen.

The theralitic modification shows a fairly sharp junction with the next lowest which proves to be a fresh, compact, subophitic augite teschenite identical with the rock on the eastern slopes of Mons Hill. No chilling is seen at the junction of the theralite and the augite teschenite which does not contain segregation veins.

Passing downwards we find a sharp but unchilled junction between the compact sub-ophitic teschenite and the very coarse, ophitic augite teschenite which forms the bulk of the sill. This central modification is identical with some of Rohrbach's diabasic teschenites./

teschenites. The large ophitic prisms of purple titanaugite measure up to ½ in. across and 6 in. in length. They are penetrated by large zonal plagioclase tables which are partially analcitised. Occasional green pseudomorphs after olivine occur but they are not common. The rest of the rock is made up of allotriomorphic alkali felspar, analcite, and natrolite with accessory ilmenite (in large sheletal crystals), biotite and apatite. Calcite frequently fills cavities in the rock and chlorite is everywhere abundant. The rock is porous and crumbly. Druses containing zeolites are often very conspicuous.

The central augite teschenite contains one type of segregation vein. This type is pink in colour, of medium grain, and is exceedingly porous. In thin section simply-twinned crystals of alkali felspar are seen to make up the bulk of the rock. They are turbid with brown decomposition products and partly replaced by cloudy analcite and fresh natrolite. Occasional small crystals of ilmenite and a few chloritic pseudomorphs after some ferromagnesian mineral are also to be seen.

The coarse central modification gives place downwards/

downwards to a more compact sub-ophitic augite teschenite very like the upper one and this in turn is succeeded by a theralite exactly similar to that of the upper zone. Below this, however, and merging into it, occurs a coarser sub-ophitic hornblende teschenite from which nepheline appears to be absent. The barkevikite prisms in this rock vary greatly in size and are partly chloritised.

The above modification shows a sharp unchilled junction with a singularly beautiful augite teschenite which shews a strong resemblance to the rock of Salisbury Crags, but is much fresher. The titanaugite of this rock shows ophitic structure but rarely and most of the titanaugite crystals are strikingly idiomorphic. This is the modification that was analysed by Mr E.G. Radley, and it continues downwards with variations in grain until the outcrop of the sill disappears under the sand of Peatdraught Bay.

The segregation veins of the lower modifications are exactly similar to those of the upper, but the pink veins are, on the whole fresher and show, in places, unmistakeable hexagonal pseudomorphs after nepheline.

One of the most striking features of the Mons Hill/

Hill Sill is the great variety and capriciousness of texture which seems to indicate that the magma intruded was exceedingly aqueous and mobile. It is very difficult to give estimates of the thickness of the various modifications as it is not known whether the dip changes across the outcrop. It is, however, fairly clear that the central modification is by far the thickest and that the apparently great thickness of the upper theralitic modification is due to it being observed along a strike section.

Turning next to the inland exposures, we find the central augite teschenite represented along the escarpment of Mons Hill and Crossall Hill. Lower down on the eastern slopes the more compact sub-ophitic augite teschenite may be seen in a very fresh condition. The rock is mottled black and white in colour and of medium grain. It shows analcitisation of the plagioclase clearly, and appears to be rich in soda orthoclase. Olivine, pseudomorphed by brownish-green serpentine, is quite common and biotite is a fairly abundant constituent. Some of the smaller titan-augites are nearly euhedral, but the larger ones show a subophitic relationship with the felspar and sometimes enclose small laths of plagioclase. No hornblende/

hornblende is present, but in one section a small crystal of nepheline showing a rectangular outline was noted. This, together with a similar crystal in the augite-teschenite of Dundas were the only two occurrences of nepheline in augite-teschenite, found in the district.

The Dickson's Craig teschenite is presumably a faulted off portion of the Mons Hill sill. The rock is here very uniform in character and is quite similar to the rock from Mons Hill described above. It may, however, be distinguished from all the neighbouring teschenites by the occurrence of thomsonite as an ubiquitous constituent.
The absence of hornblende from all the inland exposures is curious.

At Port Edgar the Mons Hill Sill shows no petrographical differences from the eastern outcrop, but again hornblende is found to be absent and sub-ophitic and ophitic augite teschenites are the only modifications found. The rock here is,on the whole, ill-preserved.

CRAMOND SILLS.

The two small teschenite sills near Cramond Village prove to be sub-ophitic augite-teschenites which/

which are peculiarly rich in analcite and biotite.[1] The titanaugite has an unusually rich purple tinge, and the plagioclase has undergone almost complete analcitisation. Barkevikite occurs sporadically as separate prisms and in parallel growth with titan-eugite in a marginal facies of the east sill. This is the only occurrence of barkevikite in the district, other than at Whitehouse Point.

CRAIGIE SILL.

The augite teschenite of Craigie presents no unusual features and, except for the absence of thomsonite, is very similar to the rock of Dickson's Craig. The quantity of analcite is, however, variable and shows a distinct falling off at Clove Craig. While some of the smaller crystals of titanaugite are nearly euhedral, the larger ones frequently show marked ophitic relationship with the plagioclase laths which penetrate them in all directions. Natrolite is of common occurrence in this intrusion.

A pink segregation vein from Dolphington Quarry is interesting. It is of medium grain and granitic texture, consisting mainly of alkali felspar (soda-orthoclase?) and biotite which occurs as large flakes. Analcite/

(1) "The Geology of the Neighbourhood of Edinburgh" Mem. Geol. Sur. p.296.

Analcite replaces the felspar in patches to a large extent and also appears as a primary mineral in large patches. These patches frequently enclose small shapeless crystals of a green pyroxene which has all the properties of aegirine. Green pyroxene is also enclosed by alkali felspar and appears in this case to be aegirine augite, the extinction angle rising to 25°. A few small crystals of ilmenite make up the remainder of the rock.

DUNDAS SILL.

The rock from Carmelhill Quarry is decidedly pink in colour and variable in grain. Under the microscope it proves to be a sub-ophitic augite teschenite unusually rich in alkali felspar, and is very similar to the rock from the east slopes of Mons Hill. It contains however small crystals of aegirine augite which are usually enclosed in patches of analcite. Aegirine augite may also be seen as a marginal phase of the normal purple titanaugite but has here an extinction angle of about 30 - 35° while the extinction angle of the isolated crystals may drop as low as 23°. In one section there is a single small/

small crystal of nepheline. No material fresh enough for a detailed petrographical examination was found elsewhere but it may be remarked that the rock from a small quarry near Dundas Castle appeared to be a decomposed analcite dolerite, which is indicative of a falling off in the quantity of analcite, as at Clove Craig in the Craigie Sill.

LINDSAY'S CRAIGS SILL.

The sub-ophitic augite teschenite of Lindsay's Craigs is one of the most leucocratic in the district, and is very rich in biotite. It contains some very large patches of limpid analcite which enclose biotite flakes and needles of apatite. The rock, however, is rather decomposed and much of the purple titanaugite is chloritised.

OBELISK HILL SILL (BRAEFOOT 2)

The rock of Braefoot 2 is of a remarkably uniform appearance all the way round its U-shaped outcrop. It is very hard, dark, and compact, is of fine to medium grain, and possesses the pinkish tinge often associated with teschenites. Its porphyritic character is/

is not very evident in the hand specimen. Large rounded phenocrysts of olivine form the most conspicuous constituent under the microscope. They tend to form glomero-porphyritic groups with idiomorphic titanaugite phenocrysts which are also common. The olivine is often entirely unaltered. The groundmass consists of small idiomorphic titanaugite prisms together with small laths of plagioclase and abundant analcite which is usually turbid. Minor constituents include alkali-felspar, doubly refracting zeolites, biotite, ilmenite, and apatite, this last mineral forming hexagonal prisms of a much larger size than usual. The analcite has in places corroded the plagioclase, but the latter mineral may be seen quite fresh and appears to range from labradorite to oligoclase. Where the analcite comes into contact with other zeolites it invariably presents idiomorphic faces towards them, but is allotriomorphic towards all the other minerals, filling the interspaces of the rock as do the other zeolites. A superficial examination of sections from the summit of Obelisk Hill showed the apparent anomaly of small titanaugitic crystals enclosed in large phenocrysts of olivine. On a more detailed examination, however, it was seen that after the olivine had solidified, the/

the magma made its way along the cracks in that mineral and crystallised out finally as titanaugite and felspar. At Obelisk Hill the abundance of the doubly-refracting zeolites increases at the expense of analcite and these zeolites are seen to replace plagioclase in the manner of analcite. No nepheline was observed in this rock which is the only example of the basaltic type of teschenite in our district. It differs from the rock of Spalefield by absence of barkevikite and the presence of doubly-refracting zeolites.

GENERAL NOTES. A few specific gravity determinations of teschenites may prove of interest.

A. Basalt Type	(Obelisk Hill	2.87
	(Spalefield	2.85
B. Dolerite Type	(Dundas	2.71
	(Lindsay's Craigs	2.74
	(Mons Hill (centre)	2.74
	(Dolphington Quarry	2.75
	(Cramond (east)	2.76
C. Gabbro Type	(Bugar	2.67
	(Cranhill	2.89

The agreement of all the figures in group B is very striking and higher values given by the compact basaltic/

basaltic type are also to be noted. In group C it is unfortunate that the Lugar rock is abnormally leucocratic while the specimen from Cranhill was extremely melanocratic. The Whitehouse Point theralite gives the figure 2.75. It is unusually rich in analcite for a theralite, but on account of its high nepheline content it can only be reckoned as a theralite with teschenitic affinities.

PETROGRAPHY OF ANALCITE DOLERITES.

The occurrence of decomposed analcite dolerite as a marginal phase of the Dundas Sill has already been mentioned. A similar rock occurs 300 yards east of Cramond Village, but is still more decomposed. The analcite of both these rocks has been replaced by calcite and the felspar is the only mineral in a state approaching freshness. Neither rock is worthy of further attention.

HALLCRAIG SILL (BRAEFOOT 1).

Like the rock of Braefoot (2), that of Braefoot (1) has a very uniform appearance right round its semicircular outcrop. It is light green in colour and/

and of medium grain. Sections from Braefoot show the rock to be an analcite-dolerite of a type very similar to some of the sub-ophitic augite teschenites which are poorer in analcite (e.g. the rock of Clove Craig) and quite unlike the porphyritic rock of Gosford Bay. The only differences noticeable from such teschenites as that of Clove Craig are (1) the comparative paucity of analcite (and the consequent absence of analcitisation in the plagioclase), and (2) the occurrence of brown hornblende as a marginal growth on some of the pyroxenes which are less purple than in the teschenites. The rock of Hallcraig is much more decomposed and veined throughout with chalcedony. All the ferromagnesian minerals are replaced by carbonates, chlorite and occasional grains of quartz; olivine and augite pseudomorphs, however, may be clearly recognised by their shape. Analcite has been replaced by calcite, but the felspars are remarkably fresh. Originally the rock must have been very like that of Braefoot.

PETROGRAPHY OF ANALCITE BASALT. (Plate I Fig 6)

The rock of the small sill in Dalgety Bay is of a somewhat peculiar type and is perhaps to be looked/

looked upon as a rapidly cooled phase of the teschenite of Obelisk Hill which it resembles greatly in appearance. Under the microscope rock is seen to consist of large rounded phenocrysts of olivine (usually quite fresh) in a groundmass consisting of groups of small titanaugite prisms, plagioclase laths, and analcite which is nearly always turbid. Apatite, ilmenite, and biotite occur as accessory minerals. The porphyritic character of the rock is exceedingly well marked.

PETROGRAPHY OF DALMENY BASALTS.

As both the rock of the Buchans and that of Porthaven are absolutely identical with the type rock from Dalmeny the writer will be content to give the reference to the description of the latter in the Edinburgh Memoir which he confirms in every point.(1)

The specific gravity of the Dalmeny Basalts varies between 2.85 and 2.90.

PETROGRAPHY OF QUARTZ DOLERITES.

The quartz Dolerite sills of Central Scotland are so uniform in their petrographical characters that/

(1) "The Geology of the Neighbourhood of Edinburgh" Mem. Geol. Sur. p.319.

that one description answers for all. The sills of Ratho and West Craigs are both well-known as quartz hypersthene dolerites and have been fully described by various authors. The most complete description of the quartz dolerites of sheet 32 is that given by Dr Flett in the Edinburgh Memoir and it fully covers all the sills in our district.(1) The writer only wishes to add that he considers that the division of the quartz dolerites into the Bowden Hill and Ratho types by Prof. Watts, on the grounds of their relative abundance of micropegmatite, is unnecessary. Both types occur sporadically in the same sill in many localities and intermediate types are exceedingly abundant. The presence of hypersthene in the Hound Pt. sill does not appear to have been previously recorded; so it may be stated here that this mineral occurs abundantly in excellent preservation ¼ mile west of the Fish Pond below New England. (PLATE 2, FIG. 2)

Reference has already been made to the aphanitic quartz dolerite in the railway cutting at Dalmeny. Specific gravity determinations were taken of several fresh specimens of quartz dolerite, and all gave the value 2.85.

(1) "The Geology of the Neighbourhood of Edinburgh". Mem. Geol. Sur. p.301-308.

S U M M A R Y.

The following are the principal points described in this thesis:-

(1) A well-marked pre-glacial dry valley has been discovered between Castle Craig and New England.

(2) The Hound Point Sill has been traced south as far as the Ochiltree Fault, and the mapped area of the Mons Hill Sill is thus greatly reduced.

(3) 75 ft. or more of bedded basaltic tuff has been found at Mansion Hill.

(4) A new volcanic horizon has been discovered at the Buchans which were found to consist not of quartz dolerite but of Dalmeny basalt.

(5) The Scottish teschenites have been classified and divided into three groups:-

A. Porphyritic or Basalt Type

B. Ophitic or Dolerite Type

C. Non-ophitic or Gabbro Type.

(6) A new and unique type of teschenite from Obelisk Hill, Aberdour, has been described.

(7)/

(7) A theralitic modification from the Mons Hill Sill at Whitehouse Pt. has been described.

(8) Nepheline has been detected for the first time in a British rock belonging to group B. of the teschenites.

(9) Aegirine-augite has been recorded in the Dundas teschenite sill and aegirine itself has been detected in a pink segregation vein of the Craigie teschenite.

PLATE I.

Fig (1) Sub-ophitic or dolerite type of teschenite.
Shore ¼ mile east of Cramond Village.
Ordinary light X 25.
Sub-ophitic crystals of titanaugite, clear patches of analcite, and iron ores are conspicuous in a turbid aggregate consisting mainly of analcitised plagioclase.

Fig (2) Non-ophitic or gabbro type of teschenite.
Cranhill, Glasgow.
Ordinary light X 25.
Large euhedral titanaugites, showing hour-glass structure, set in aggregate of clear analcite, turbid analcitised plagioclase, iron ores, and serpentine.

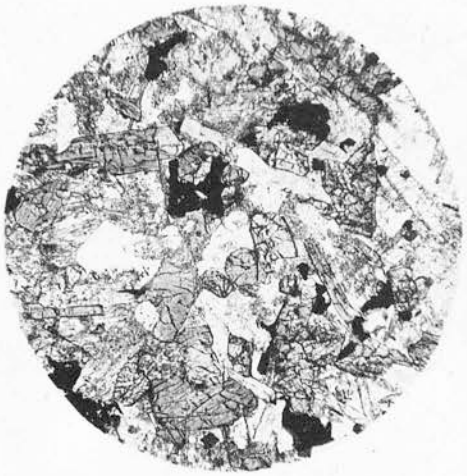
Fig (3) Porphyritic or basalt type of teschenite.
Obelisk Hill, Aberdour.
Ordinary light X 25.
Phenocrysts of fresh olivine and titanaugite, and large crystals of iron ores set in a turbid groundmass of titanaugite, felspars, and zeolites.

Fig (4) Crinanite, Mingulay, Outer Hebrides.
Ordinary light X 35.
Note the dark strongly ophitic pyroxene, the granular olivine, and the freshness of the leucocratic minerals as compared with teschenites. A circular analcite-filled vesicle is conspicuous.

Fig (5) Theralite. Whitehouse Point.
Ordinary light X 50.
Elongated prisms of barkevikite, and shorter prisms of titanaugite show strong idiomorphism and are set in an aggregate of analcitised plagioclase, analcite, and nepheline.

Fig (6) Analcite basalt. Dalgety Bay.
Ordinary light X 50.
Large rounded phenocrysts of olivine set in a groundmass of titanaugite, plagioclase, and turbid analcite.

(1)



(2)

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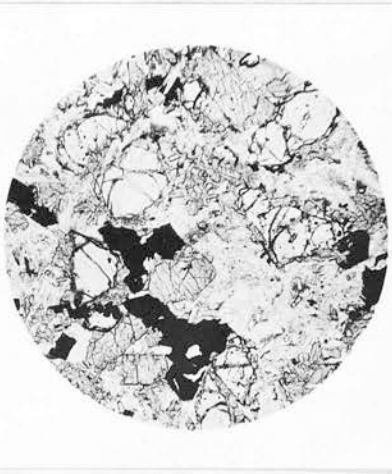

(4)

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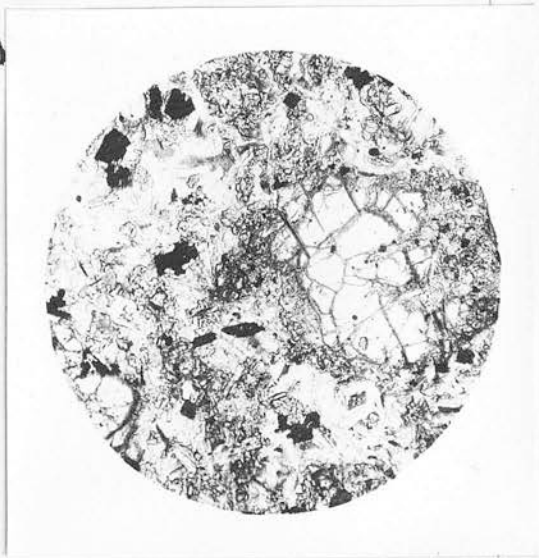


PLATE II.

Fig (1) Ophitic dolerite. Shore ½ mile east of Cramond Village.
Ordinary light X 50.
Note the strongly ophitic pyroxene and the great variety in the size of the plagioclase laths.

Fig (2) Quartz dolerite. ¼ mile south of Castle Craig.
Ordinary light X 25.
A conspicuous group of hypersthene crystals is seen near the centre of the field and monsclinic pyroxene is abundant to the left of this.

Fig (3) Ice moulding on teschenite. Dickson's Craig Quarry.

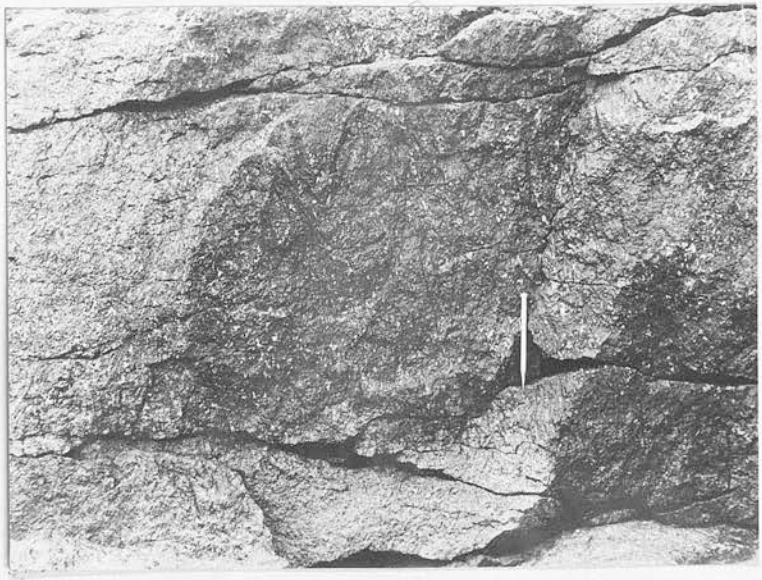
Fig (4) Coarse crystallisation of central augite teschenite in Mons Mill Sill at Whitehouse Point. White druses may be seen and long prisms of titanaugite.

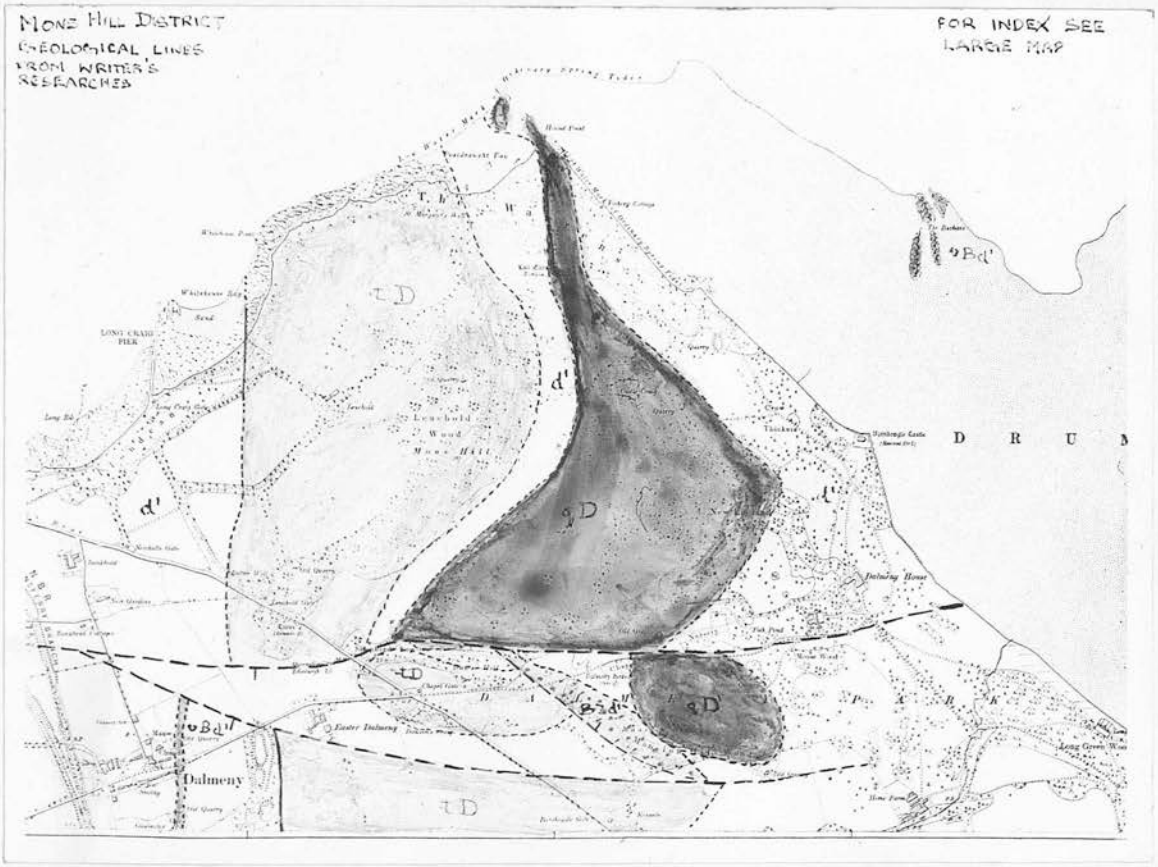
(1)

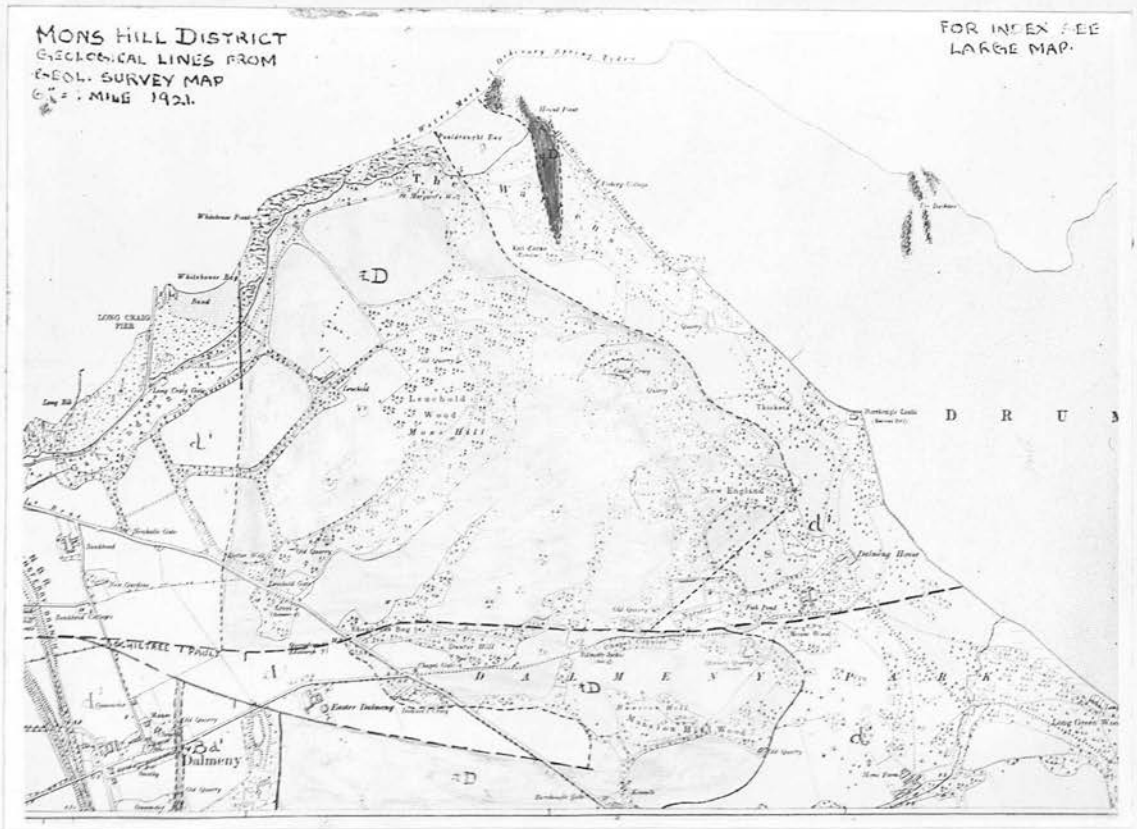
(2)

(3)

(4)




MONS HILL DISTRICT
GEOLOGICAL LINES FROM WRITER'S RESEARCHES
FOR INDEX SEE LARGE MAP
Dalmeny
D R U M
D A L M E N Y P A R K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SECOND EDITION, 1897.

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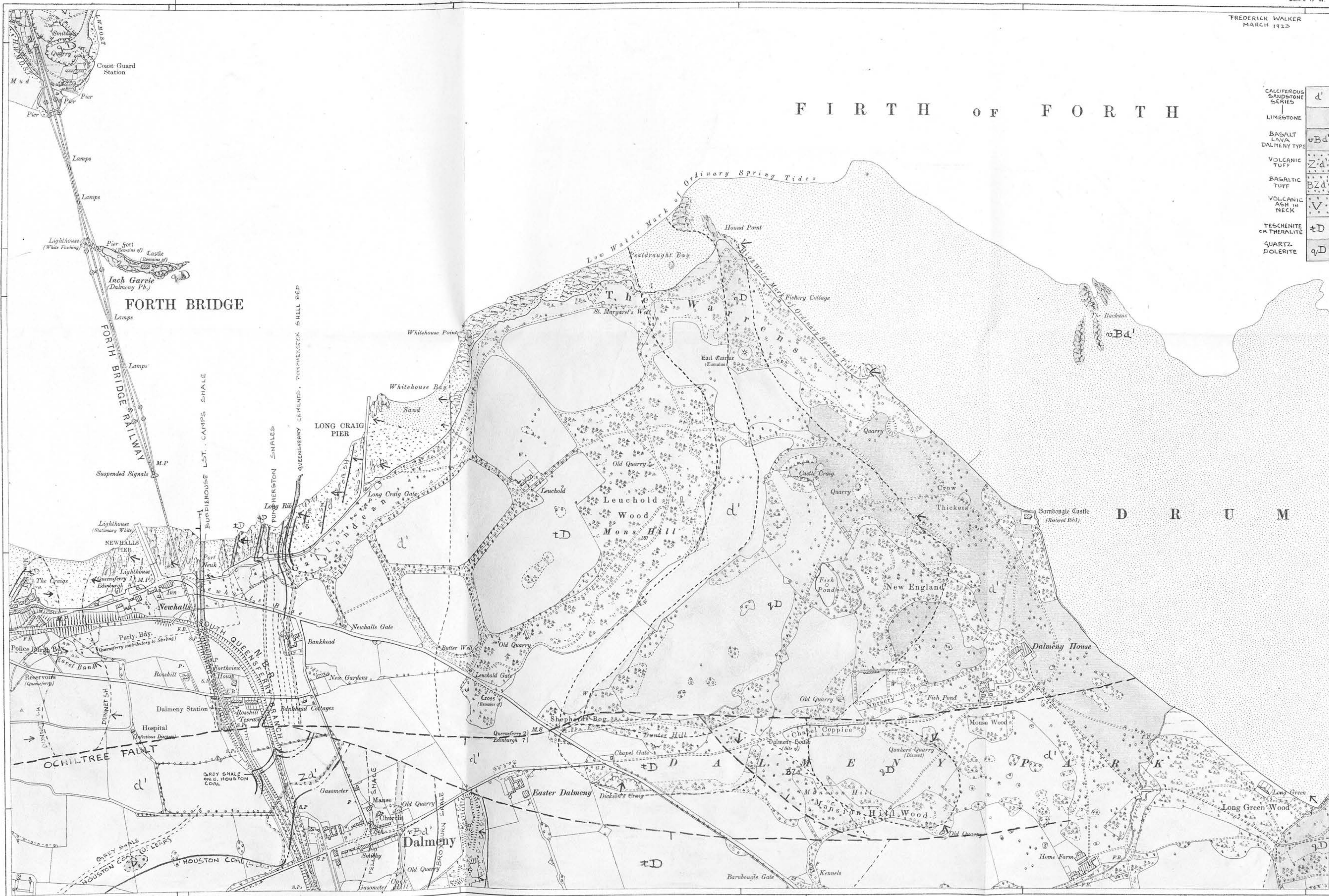

FIFESHIRE WESTERN DIVISION

QUEENSFERRY PARLY. MUNL. & POLICE BURGH

LINLITHGOW. III. S.E.

LINLITHGOWSHIRE DALMENY PH.

Surveyed in 1854. Revised in 1895.
Reprint 100/21.

Altitudes are not published for this Sheet.

CHARACTERISTICS AND SYMBOLS.

County Boundary
Parish Boundary
Contours { Instrumental 200 / Sketched 225 }
Antiquities, Site of
Arrow, showing direction of flow of water
Trigonometrical Station
For other information see Characteristic Sheet.

Price 1/6 net.

Scale—Six Inches to One Statute Mile or 880 Feet to One Inch = 1/10560

Heliozincographed from the Plans and Published at the Ordnance Survey Office, Southampton.

N.B.—The representation on this map of a Road, Track, or Footpath, is no evidence of the existence of a right of way.

The Altitudes are given in Feet above the assumed Mean Level of the Sea at Liverpool, which is 0·650 of a Foot below the general Mean Level of the Sea.

Altitudes indicated thus (B.M. 54·7) refer to Bench Marks on Buildings, Walls, &c., those marked thus (·) preceded or followed by the height, to surface levels.

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