

In the Horton district we appear to have a normal succession. On Ingleborough, above the *Caninia* basement bed S_2 is represented by the *Bellerophon* bed with *Nematophyllum minus*, and is in all respects similar to the same zone on Scout Scar, Hampsfield Fell, etc. Above these, beds rich in *Chonetes papilionaceus*, *Lithostrotion Portlocki*, and *Alveolites septosa* succeed, and corals allied to *Dibunophyllum* ϕ are not uncommon still higher with characteristic *Producti*. But I do not know of the occurrence of *Lonsdaleia floriformis* or *Productus giganteus* on Ingleborough. On Penygent, however, at Hunt Pot, we have a rich fauna of upper *Dibunophyllum* age containing, beside the typical *Productus giganteus*, *Lonsdaleia floriformis*, *Dibunophyllum* aff. ψ , *Lithostrotion junceum*, etc. In the lower shale band a *Spiriferina* closely related to *octoplicata* is common, and Dr. Vaughan tells me that he has lately traced Sowerby's type-specimen of *Spiriferina octoplicata* to an horizon which appears to be D_2 , the identical horizon of the Hunt Pot Beds.

The bed above this on Penygent is frequently crowded with *Productus latissimus* and thick reefs of *Dibunophyllum* in the ψ stage, a form which appears to be larger and longer than the typical examples. This bed is represented on Ingleborough by the cement-stone bed seen in the swallowhole dedicated in the Ordnance map to Tatham's wife, and is also found at Riblehead. The same zone occurs in the Wensley Dale district at the top of the Hardraw Scar Limestone, while the bottom of that bed is full of typical *Productus giganteus*.

The highest zone in the district, that contained in the Upper Scar Limestone, shows a further modification of the giant *Producti* to a form which, some years ago, I tentatively referred to the variety *Edelburgense*.¹

IV.—THE ROCKS OF NORTHERN GUERNSEY.

By JOHN PARKINSON.

Introduction.

IN a communication to the Geological Society in 1900 I had occasion to compare the rocks of the south-eastern coast of Jersey with the hornblende gabbro, diorites, and granites of Northern Guernsey; and to point out that in general terms the petrographical types of the two islands bore a close resemblance to each other, group for group, in sequence and general relations. Since work abroad renders it improbable that I shall be able to devote much additional time to this subject, the following notes are given as a possible aid to future observers.

The very valuable work of the Rev. Edwin Hill² in this island renders superfluous any lengthy note on general characters; suffice it to say that the southern part of the island consists of gneiss with a few intrusive masses and dykes; the northern of diorites and intrusive granites, except for an oblong area on the eastern coast,

¹ I here limit the term *giganteus* to the large coarse-ribbed forms found, as far as I am aware, only in the *Dibunophyllum* zone, and usually confined to the upper part of that zone.

² Quart. Journ. Geol. Soc., vol. xl (1884), p. 404 and map.

between St. Peter's Port and St. Sampson's, which is composed of hornblende gabbro.

In the present paper the field evidence will be briefly reviewed, and reference made to the microscopic work only when necessary.

The subject can be divided into two parts—

- (1) The hornblende gabbro.
- (2) Sections on the northern and western coasts.

(1) THE HORNBLENDE GABBRO.

Detailed examination of the coast between St. Sampson's and St. Peter's Port resulted in the following conclusions:—

(a) A hornblende-labradorite rock, the former mineral more or less completely replacing augite, is characteristic. The rounded outlines of the ferromagnesian mineral give a spotted appearance to this rock, which may be considered as typical of the locality ('bird's-eye' of quarrymen). It varies remarkably, however, in the relative quantity of the distinctive minerals present, i.e., either felspar or ferromagnesian constituents may predominate; such alteration taking place, sometimes as a gradual change, sometimes as a more rapid alternation of parts, of the nature of banding, in which the constituents are equally distributed.¹ A common variation results in a fine-textured rock, more basic than the average, in which the hornblende is original and not secondary, elongated prisms predominating instead of a rounded poecilitic form of augite; and the mineral, as seen in a thin section, is almost opaque through the presence of opacite. A banded structure, the occurrence of less clear and well-defined streaks differing mineralogically from the surrounding rock, and the parallel arrangement of such a mineral as hornblende indicate fluxional movement, and give rise to the irregular approximation of varieties differing considerably in composition.

(b) Later dykes cut these rocks, and belong to at least two periods. The earlier are rich in hornblende; the later, often very abundant, consist almost entirely of felspar.

A thin section of the former shows that hornblende composes at least half the rock. It forms polygonal grains (average size .009 inch, but frequently considerably larger, say .03 inch), which approach to an ophitic structure through the earlier consolidation of the felspars, but have a tendency to gather into groups of grains to the entire exclusion of this mineral.

The more acid dykes show a strong tendency to follow the directions taken by the earlier system, with the result that a kind of composite dyke is produced. The variations in the hornblende gabbro go to show that a rock which forms a dyke in one place may in another pass gradually into one on the whole older which surrounds it. This close relationship is strongly borne in upon the observer. Especially noteworthy are the large elongated hornblendes in the felspar dykes, producing a close resemblance to the extreme feldspathic variation of the 'bird's-eye.' The dimensions of the dykes exercise no influence on the dimensions of the hornblende.

¹ See Professor Bonney's description: *Quart. Journ. Geol. Soc.*, vol. xl (1884), p. 425. Mica is rare in these rocks.

A thin section cut from one of these shows that the characteristic mineral is obscured by secondary products, but such extinctions as can be seen indicate labradorite. The crystals are occasionally zoned. A few grains of apatite and ilmenite are the only accessory minerals.

The felspathic dykes contain also darker shreds and inclusions, sometimes clearly, sometimes indefinitely outlined, suggesting that a local absorption of derived fragments attended the intrusion. Occasionally a more definite arrangement of parts produces a rude banding. Thus in one instance the centre of such a dyke, cutting the ordinary 'bird's-eye,' was dark-coloured and close-grained, about $1\frac{1}{2}$ inches across, and bordered by a narrow felspathic edge, not sharply marked off from the surrounding rock, while one or two identical felspathic patches were contained in the central part and were disposed roughly parallel with the direction of the dyke.

The dioritic rock, referred to under the heading Hornblende Gabbro (*a*), is found also as ill-defined fragments lying in a more felspathic matrix, which nevertheless contains a considerable quantity of hornblende. Other inclusions occur, petrologically inseparable from the hornblende dykes, while the rocks rich in felspar in which they lie are indistinguishable from the later dykes when these contain hornblende.

A note by the Rev. Edwin Hill and Professor T. G. Bonney on a banded specimen of 'long-grain' and felspathic rock from here, is of interest in this connection.¹ The inferences drawn as to the possible derivation of the hornblende from augite and the occurrence of biotite as a derivative from the former mineral are entirely in accord with my own work, as is also the conclusion that the rock "exhibits an imperfect mixture of two magmas" (p. 137). A slight difference in the physical state of either or both of the magmas may give rise on the one hand to a brecciation, on the other to interbanding.

Examination of Bordeaux Harbour and the shore between Hougue à la Perre and St. Peter's Port did not appear to me to warrant the conclusion that the hornblende gabbro was genetically distinct from the dioritic rocks to the north and south.

(2) SECTIONS ON THE NORTHERN AND WESTERN COASTS.

(*a*) *East Shore of Grande Havre.*—The quarry at the south-east angle of Grande Havre is excavated in a fine-grained mica diorite containing a little quartz. A thin section shows that the hornblende is intimately associated with biotite, which apparently replaces it, and forms a kind of matrix to the other minerals. A coarser rock consisting of plagioclase, some orthoclase, and a considerable quantity of quartz (sometimes a full third of the rock) is intrusive into it. The junction, which is not very clearly defined, is made apparent by the greater size of the felspars of the more acid rock, accompanied by the development of biotite to the exclusion of hornblende. The quartz has corroded the felspar. The more basic side of the junction consists of plagioclases varying from oligoclase to labradorite, usually

¹ Quart. Journ. Geol. Soc., vol. xlviii (1892), p. 135.

with a more translucent border, a little quartz, a considerable quantity of brown mica in flakes up to .028 inch across, and green hornblende taking the form of rounded polygonal grains. Further observation shows that the younger of the two varies greatly in composition, and, although usually containing hornblende and conspicuous crystals of biotite, yet the dark minerals may be locally absent or represented by a group of irregularly disposed and elongated hornblendes, always considerably larger than any of the other constituents. Naturally there are many minor variations. For example, a slab may consist of two slightly different rocks, distinguished principally by their relative amounts of hornblende; the less basic containing drawn-out patches of a finer textured and darker rock. Fluxional movement is indicated by bands of different mineral composition, which occasionally are traceable for eight or ten feet. The almost invariable presence of quartz and the common occurrence of large ragged plates of biotite distinguish these rocks at once from the hornblende gabbro of the east coast.

(b) *The East Coast North of the Hornblende Gabbro.*—At Hommet Bennest, to the north of Bordeaux Harbour, we find a close-grained diorite weathering grey through the presence of felspar, which predominates slightly over the hornblende. This rock is veined and streaked by one still more felspathic, which contains a ferromagnesian mineral. The older of the two rocks consists of a felspar too opaque for determination, slightly earlier in consolidation than the hornblende, an altered mica, and a little magnetite. Small patches of quartz and a translucent felspar are found here and there. Hornblende bordering these patches assumes the form of an actinolitic fringe. Comparison with other slides suggests these patches are the early stages of a permeation by a more acid magma.

(c) *From Vale Castle to Fort Norman.*—A uniform blue-coloured quartz-diorite with no clear signs of veining or intrusion is quarried along the shore to the north of Vale Castle. This is a variety of the older rock of Grande Havre Quarry—a quartz-mica diorite. We meet with a very similar rock to the west of Lancrese Common, but differing in being richer in quartz and biotite. In both slides the felspars are often zoned, the outer border more translucent than the centre, while the higher extinction angle and irregular outline of the central part suggests the corrosion of a basic species. A little more than half-way between the Castle and the Fort the diorite is cut by a lighter-coloured and coarser rock, containing, however, some quantity of hornblende, which locally assumes an elongated outline.

The character of the intrusion is irregular and streaky. On a jutting headland to the south of the Fort is a fine-grained diorite like that of Hommet Bennest, consisting of hornblende and felspar, the latter slightly the earlier in crystallization, some is untwinned, but plagioclases occur varying from oligoclase to labradorite. It is broken by veins or dykes of a felspathic rock speckled with hornblende. Occasionally dykes, about an inch wide, can be traced for five or six feet. A thin section across the junction exhibits the following association: a fine-grained quartz-free hornblende plagioclase rock on the one side, a coarser quartz hornblende felspar rock on the other.

The latter is the intruder, but the boundary between the two is quite indefinite, partly no doubt owing to the opaque state of the felspars, which hinders a precise determination. In the older rocks the hornblende formed after the plagioclase, and is locally replaced by biotite; in the younger the quartz is inconspicuous, and plagioclase is plentiful (oligoclase to labradorite), with a tendency towards idiomorphism.

A striking contrast exists between this rock and the intrusive member at Grande Havre. Not only is the latter coarser, but its plentiful quartz and biotite distinguish it at once from any rock on the east coast, while the former is not unlike the late felspathic dykes cutting the hornblende gabbro.

(d) *East and South of Fort Marchant.*—At the southern end of the Fort Marchant peninsula the diorite contains rounded hornblendes, resembling the spots on a trout, with which is associated a variety containing the same mineral as elongated prisms. Both are veined by a third rock, richer in felspar (some orthoclase and acid plagioclases), and containing a little quartz, some biotite, and green hornblende.

This assemblage, for the members cannot well be separated, passes into a rock which, although poorly developed, is identical with the 'bird's-eye' of the shore to the north of St. Peter's Port. It contains segregations of hornblende and locally more felspathic patches containing hornblendes, connected in some instances with irregular veins.

Similar phenomena of variation, and intrusion which may be called intermingling, are abundant elsewhere in the northern part of the island. Thus we find evidences of a brecciation more or less sharply defined all over the quarries near the Saumerez Monument.

The younger rock is of a more granitic composition than that into which it has forced its way, and when pure, i.e. unassociated with fragments, seemingly not rich in either black mica or hornblende. The older rock is a quartz-diorite, on the whole uniform in texture, but which contains more basic fragments, having edges sometimes well defined, sometimes passing into the surrounding rock in a cloudy way, a zone half-an-inch or so wide being common to both.

Locally the invading rock is distinctly streaky; the whole suggesting that the older member was in a state of imperfect consolidation at the time of the intrusion of the more acid magma, and that some absorption took place.

The hornblende-felspar rocks south of Fort Norman and from Hommet Bennest are essentially the same as the more basic parts of rocks from the west of Fort Doyle and the black dykes cutting the 'bird's-eye' of the St. Sampson's area.

Conclusions.

1. That in the northern half of Guernsey we have a series of igneous rocks, which, with the probable exception of some granites on the west coast, are related to each other as the products of differentiation of a single magma.

2. Some evidence exists for a progressive increase in acidity in going north and west.