Minor igneous intrusions - Jersey: description of 1:25 000 Channel Islands Sheet 2

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Jersey (Channel Islands Sheet 2). 1:25 000 series - Classical areas of British geology

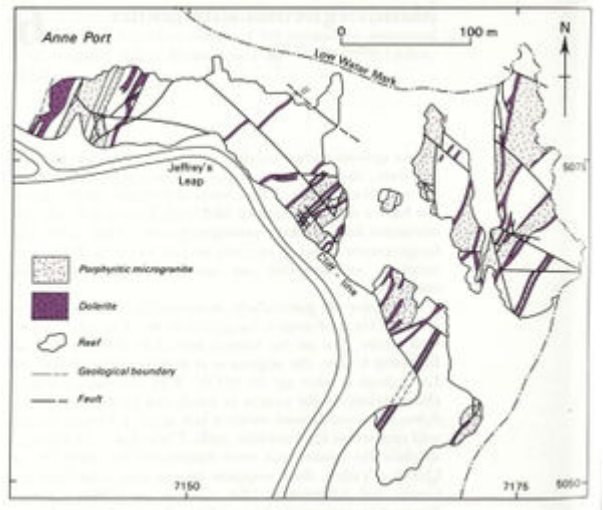

Figure 15 Sketch map showing dykes exposed in reefs at Jeffrey's Leap. Redrawn from Thomas, 1977, fig.10.1.

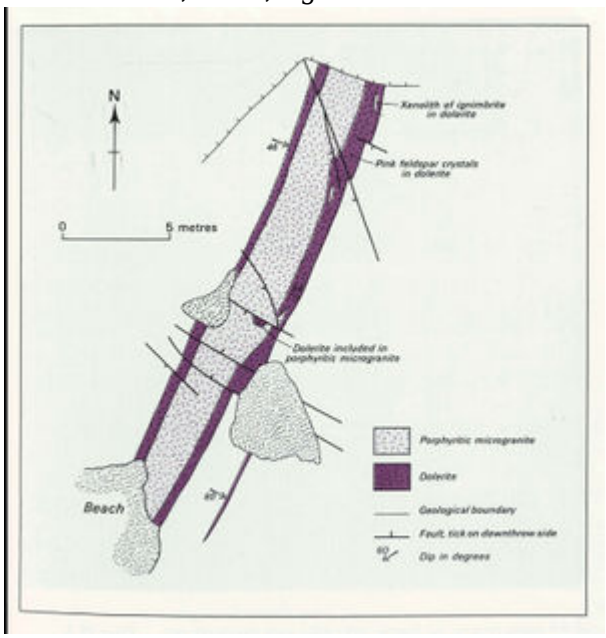

Figure 16 Sketch plan of a composite dyke at Petit Portelet. Redrawn from Thomas, 1977, fig. 10.4.

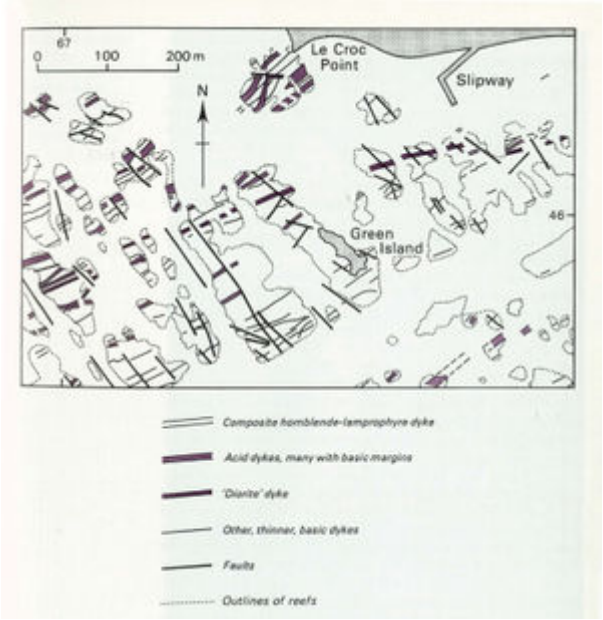

Figure 17 Sketch map of the area around Green Island, showing the displacement of dykes by faults. Many small basic dykes have been omitted for clarity.


Plate 13 A composite dyke at Jeffrey's Leap, Anne Port, has dark doleritic margins separated by pale porphyritic microgranite. (A13700).

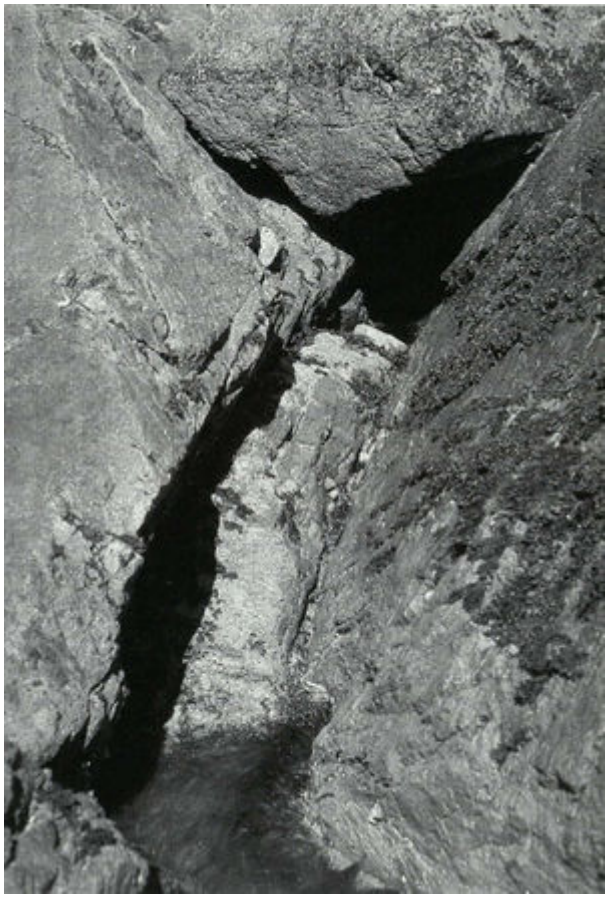

Plate 14 A dyke of micalamprophyre in granite below Mont Orgueil Castle, Gorey. (Photograph by Dr A. C. Bishop).
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Contents

Chapter 6 Minor igneous intrusions

Minor igneous intrusions abound in all the Channel Islands. In Jersey, most are dykes (in the generally accepted usage of the term for vertical or near-vertical intrusive sheets) but a few have a subhorizontal sill-like form. Petrographically the intrusions fall into three principal groups–basic, acid, and lamprophyric–each containing several varieties. Field relationships indicate that the intrusive history has been complex.

The dykes are particularly numerous in the south of the island. This main swarm has a general W–E trend in southwest Jersey, but on the eastern side of St Aubin's Bay, at Elizabeth Castle, the

alignment is slightly north of east. At La Collette it takes up the WSW–ENE orientation that is characteristic of the swarm in south-east Jersey, where the dykes are concentrated within a belt about 2.7 km wide and well exposed in the intertidal reefs. These dykes are exposed sporadically inland and were intersected by boreholes at Queen's Valley; they reappear on the east coast between Gorey and Archirondel (for example, at Jeffrey's Leap, (Figure 15)), apparently having been displaced somewhat to the north.

Basic intrusions

Basic intrusions are more abundant than the other petrographic types. Most are dykes, ranging in thickness from 10 m or more to the thinnest veins, the average being about 1 m. Although most are simple intrusions, multiple and composite dykes also occur (Figure 16). Virtually all the composite dykes have basic margins and porphyritic micro-granite (feldspar-quartz-porphyry) interiors (Plate 13), but in a few this central portion is of lamprophyre. Although the composite intrusions are usually considerably thicker than the simple dykes, the basic margins are of comparable thickness–usually less than 1 m–and represent only a small part of the total thickness of the dyke. Wherever the order of intrusion has been established, the basic margins appear to have been emplaced first, followed by the acid or lamprophyric interior.

There are several compositional and textural varieties of basic dyke. The two principal ones are: dolerites containing either fresh or relict pyroxene, with or without amphibole; and basic intrusions showing various degrees of alteration both of feldspars and of coloured minerals. Aphyric, porphyritic, and ocellar varieties of each occur. Amphibole and chlorite are abundant in the altered dykes, which range from rocks in which original textures are preserved to those which are so altered as to resemble epidiorites. Brown amphibole also occurs in some of these altered dykes. The degree of alteration seems to be largely independent of the order of intrusion of the dykes (see pp. 68–70). Nearly all the dykes in the Jersey Shale Formation and in the overlying volcanic rocks are intensely altered, and many are sheared. On the other hand, dykes belonging to the main swarm of the southeast plutonic complex are principally dolerites around St Helier and at La Collette, but are almost entirely metadolerites farther east from La Grève d'Azette to Pontac. The alteration would seem not to be the result of weathering, but to be due to some form of low-grade metamorphism which affected the rocks as a whole.

Near Green Island (Figure 17) a coarse-grained basic dyke [677 461] 10 m wide has a dioritic mineralogy, and closely resembles the dioritic rocks into which it was intruded. This dyke has chilled margins and felsic pockets containing euhedral, elongated, cored amphiboles like those of the hornblende-lamprophyres (see p. 66). It is, however, distinct from them, for it intruded the camptonitic hornblendelamprophyre.

Near Seymour Tower a few basic dykes in the La Rocque granite have the form of elongate pods separated from one another by granite. They are comparable to the synplutonic dykes described by Cobbing and Pitcher (1972) from Andean plutons, and indicate the overlapping of granite emplacement and dyke intrusion. These dykes have distinctive granoblastic fabrics, as do certain dark fine-grained inclusions in the diorites at Green Island. These inclusions differ chemically from the dykes of the main swarm and could be interpreted as early dykes, probably intruded into the original gabbro and subsequently broken up and altered. Small quartzose xenocrysts, probably indicative of contamination, are widespread in the dykes in the eastern part of the main swarm. At Pontac [690 468] such dykes are cut by aplitic veins, again pointing to the near-contemporaneity of granite emplacement and dyke intrusion.

Eight basic sills, the thickest about 1 m, are exposed in the granite cliffs between Grosnez Point [549

567] and Le Pulec [549 547] on the north-west coast of the island. They dip gently south-east, so that the lowest is exposed in the north and the topmost in the south. Each individual sill is exposed along the strike for 100 m or more before thinning out. Three such sills—the greatest number in any one place—are exposed above one another near the former German radar tower at Les Landes [5450 5598], but the most spectacular is the sill which runs at the foot of Le Pinacle [5445 5545].

An extensively altered basic sill, about 0.5 m thick, is exposed on the western side of Portelet Bay [598 470] and at the foot of the cliffs surrounding the small bay immediately east of Pointe le Fret [596 468]. A differentiated composite sill, 8 to 10 m thick and dipping at 25° just east of north, is exposed at La Collette [6525 4756] (Bishop, 1964b). This sill has chilled margins, and its main mass was probably emplaced as a basic magma which was permeated by acid fluids, for it contains potassic feldspar and brown amphibole, both concentrated in bands and distributed thoughout the rock, giving it some of the characteristics of hornblendelamprophyre. The sill contains several bands of porphyritic microgranite coplanar with the contact, the most prominent being about 0.75 m from the top.

Acid intrusions

Acid intrusions are fairly widespread in Jersey, but most are confined within the dyke swarm in the south-eastern part of the island. They are generally 4 to 10 m wide and, though some are simple intrusions, many are composite with relatively thin basic margins.

There are two principal types of acid intrusion, porphyritic microgranites (or feldspar-quartz-porphyries) and flow-banded rhyolites. The porphyritic microgranites are the more abundant; they are pink- to yellow-weathering rocks, usually containing abundant phenocrysts of quartz, potassic feldspar and plagioclase in varying proportions, set in a fine-grained matrix. The quartz phenocrysts show varying degrees of resorption, and most of the plagioclase is unzoned, twinned, albite-oligoclase. The groundmass may be granular, spherulitic, or micrographic. Spherulitic fringes of varying width mantle quartz and potassic feldspar phenocrysts, and some of the dykes have a completely micrographic matrix.

Three flow-banded rhyolite dykes have been recorded—at Jeffrey's Leap [715 508], south of Mont Orgueil Castle [7154 5022], and south of St Aubin [607 482]—but their relation to the other dykes is unknown.

Lamprophyres

There are two principal types of lamprophyre in Jersey, hornblende-lamprophyre and mica-lamprophyre. The hornblende-lamprophyre dykes are much less abundant than the mica-lamprophyres.

At South Hill [6504 4764] two leucocratic hornblendelamprophyre dykes have been displaced by low-angle faults or 'shears' (Bishop, 1964a). Before land reclamation south of St Helier harbour covered the exposures, they could be seen to be cut by the La Collette sill [6497 4760], which was in turn intruded by basic dykes of the main swarm. Farther east, at Le Croc [673 462] and on the reefs to the WSW (Figure 17), a composite hornblende-lamprophyre has basic margins followed inwards by zones up to 1 m wide of porphyritic microgranite and a central mass of camptonite; this distinctive intrusion is demonstrably older than the main dyke swarm, having in places been cut by composite microgranite dykes, and it serves in assessing the amount of movement that resulted from later faulting (pp. 80–81).

Several lamprophyres have intruded the Rozel Conglomerate. A composite dyke at Douet de la Mer [7018 5418] has a central mica-lamprophyre between altered basic margins, and another south of La Coupe Point [711 538] has basic margins and a wide hornblende-lamprophyre centre.

Most of the hornblende-lamprophyres are spessartites, with long green amphibole phenocrysts set in a matrix of small tabular plagiocase crystals. Some contain a little potassic feldspar, quartz and chlorite, together with accessory minerals. The hornblende-lamprophyre at Le Croc Point [673 462] has phenocrysts of brown amphibole and is camptonitic. Smith (1936b) described as a camptonite a rock from near La Cotte à la Chèvre with phenocrysts of altered olivine, altered feldspar and fresh pyroxene, in a groundmass containing abundant small crystals of brown amphibole: it would now be grouped with alkaline olivine-basalts.

The mica-lamprophyres occur as rusty brown dykes, rarely more than 1 m wide (Plate 14), distributed throughout the island in all the major rock groups. They fall into two groups, one with a sharply defined, nearly N–S orientation, and the other scattered about a NW–SE direction. These intrusions have been described by Smith (1933, 1936a, b); they vary texturally, some having a nodular appearance and others containing ocelli, and also in points of petrographic detail, but they are the most clearly defined single group of minor intrusions.

The mica-lamprophyres, though somewhat variable, generally contain phenocrysts of biotite, many of which show colour-zoning in thin section, the margins of the crystals being more deeply coloured than the interiors. Phenocrysts of olivine (generally altered to serpentine, calcite and other minerals) and fresh pyroxene usually accompany the mica. These minerals are set in a groundmass of alkali feldspar. In most of the dykes the feldspar is fresh to turbid orthoclase, which occurs as large grains or as small radiating crystals, and justifies the name minette for these rocks. A few dykes (for example at Noirmont [607 464] and Creux Gabourel [571 563]) were stated by Smith (1936b) to contain sodic plagioclase and thus to be kersantites, but more recent work by Mr G. J. Lees indicates that they, too, may be minettes. Other lamprophyres were referred by Smith (1936b) to monchiquites because of their structureless groundmass.

Intrusive sequence

Intrusive histories have been deduced locally, but correlating these from place to place has proved difficult and it has not been possible to elucidate with certainty the overall chronographical sequence of intrusion for the Jersey dykes.

The basic dykes at Côtil Point [631 562] predate the intrusion of the Mont Mado aplogranite which, being part of the north-west granite, has a Rb:Sr isochron age of 480 ± 15 Ma (recalculated from 490 ± 15 Ma of Adams, 1976). It is not known how these dykes relate temporally to some of the early dykes in the Jersey Shale Formation.

The South Hill leucocratic hornblende-mica-lamprophyres are earlier than the La Collette sill which, in turn, has been intruded by basic dykes of the main swarm. It is doubtful whether the last are the 'older' basic dykes of La Grève d'Azette, for they and the sill have intruded dioritic rocks associated with the Fort Regent granophyre, one of the youngest of the south-east granites. Similarly, the camptonitic hornblende-lamprophyre at Le Croc (Figure 17) is cut by microgranite dykes which were themselves intruded by basic dykes.

Sills are rare in Jersey and all seem to be relatively early in the intrusive sequence. The basic sills between Grosnez Point and Le Pulec are cut by small aplite veins, and the sill just east of Pointe le Fret is cut by a N–S basic dyke.

At Noirmont and elsewhere it is clear that the main swarm of basic dykes was not emplaced as a single intrusive phase, because dykes can be seen to intersect. In south-east Jersey, dykes belonging to the main dyke swarm have intruded diorite and both the Dicq and La Rocque granites. On the intertidal reefs at La Grève d'Azette several basic dykes have intruded the Dicq granite but have themselves been truncated by aplogranite, presumably related to the La Rocque granite to the east. These older dykes have the same trend as those which have intruded both the Dicq granite and the aplogranite; because they are not petrographically distinct, it has proved impossible, in the absence of cross-cutting relationships, to distinguish older from younger dykes.

Throughout the island, basic dykes with a roughly N–S alignment cut across dykes with more nearly E–W trends, though a few N–S dykes are earlier than the E–W ones. The later N–S dykes are usually dolerites and are fresher than those they cut; a particular example, though more coarse grained than usual, is a dyke of olivine-gabbro 8 m wide at Wolf Caves [6347 5616] and its presumed continuation south of Mil Point.

The main swarm dykes appear to have been emplaced during a period of crustal relaxation. The related extension of the crust varied in direction from N–S to NNW–SSE, and judged from the thickness of the dykes its amount compares with that associated with the Tertiary dyke swarms of Mull and Skye; also, its duration was probably relatively short, about 1 to 2 Ma, similar to the estimated period for the emplacement of the Tertiary dyke swarms of Scotland (Speight and others, 1982). Dykes were probably emplaced sporadically, the later ones cutting across the earlier under the control of local features such as joints. The 'microgranite' composite dykes show spectactularly such local discordances, especially at La Grève d'Azette, but these are probably basic dykes which have tapped a source of acid magma at depth, so that special significance should not necessarily be attached to these features. Such distinctive dykes, however, show clearly—at Le Croc Point, for example—that emplacement and faulting were closely associated. The host rock to the dyke swarm, the La Rocque granite, has been dated at 509 ± 4 Ma (recalculated from 520 ± 4 Ma of Adams, 1976), so placing an older age limit on the dyke swarm. The evidence for a close temporal relationship between granite emplacement and dyke intrusion suggests an Ordovician age for the dyke swarm.

The basic, hornblende-lamprophyre and mica-lamprophyre dykes that have intruded the Rozel Conglomerate Formation (see p. 40) indicate that dyke emplacement went on well beyond the cooling period of the plutons. Adams (1976) obtained a K:Ar date of 427 ± 13 Ma (recalculated as 434 ± 13 Ma) from hornblende from the hornblendelamprophyre south of La Coupe Point, and though this age is best regarded as tentative it sets a minimum date for the deposition of the Rozel Conglomerate. Most indications from the occurrences of mica-lamprophyres in the Armorican–Hercynian belt of Europe point to a late Carboniferous–early Permian date for their emplacement (Lees, 1982).

The N–S dykes are fewer than the dykes of the main swarm and they were emplaced when crustal extension was directed roughly E–W; they are also chemically distinct from the dykes of the main swarm, being more alkaline in character. Thick N–S basic dykes occur in Brittany, where they have intruded the Cap Fréhel Sandstone of Lower Palaeozoic, possibly Cambro-Ordovician, age: alkaline basalt dykes also occur in Guernsey (the albite-dolerites). The Jersey dykes may be related to either or both of these dyke suites. Isotopic ages are not available for the acid, basic, and mica-lamprophyre dykes of Jersey, but Adams (1976) obtained a Variscan K:Ar date of 317 ± 9 Ma (recalculated as 324 ± 9 Ma) from a dolerite dyke at Roselle Point, Alderney. He also obtained a K:Ar date of 296 ± 8 Ma (now 303 ± 8 Ma) for a mica-lamprophyre from Petit Port, Guernsey, indicating a Variscan intrusion age.

Duff (1980) studied the palaeomagnetism of the Jersey dykes. He separated the dykes into three

groups, A, B, and C, all of which had trends and thicknesses characteristic of the main dyke swarm. The palaeomagnetic ages suggested for them—Carboniferous, Silurian to Middle Devonian, late Precambrian to early Cambrian, respectively—though supporting an extended intrusion history, are nevertheless surprising. None of the demonstrably late N–S dykes appears to have been investigated. It is hard to envisage how the Jersey lamprophyres (presumably mica-lamprophyres and included by Duff in Group B), which field relationships show to be the youngest of all the dykes, should have given a Silurian to Middle Devonian pole position, older than the alleged Carboniferous pole of the Group A dykes. At present it is difficult to reconcile the palaeomagnetic conclusions with the field relationships or with the few isotopic dates available.

Genesis

The dykes of Jersey—with the exception of the later N–S ones, the mica-lamprophyres, and certain early dykes intruding the Jersey Shale Formation—make up one coherent suite of rocks. This coherence, reflected in their geochemical composition, transcends differences in dyke direction, mineral composition, and relative age of intrusion. The chemical characters of the dykes have a distinctly bimodal distribution, in which the basic rocks (dolerites, metadolerites), characterised by relatively low content of Si02, and high MgO, FeO and CaO, are distinguished from the acid rocks ('microgranite), with high SiO_2, Na_2O and K_2O, and low MgO, FeO and CaO.

The basic rocks are chemically subalkaline and show typical calc-alkaline patterns for the distribution of major elements and the trace elements Y and Zr. However, calcalkaline rock suites do not normally show bimodal distribution of elements because most rocks in such suites are of intermediate composition (andesitic). Intermediate rocks among the Jersey dykes are confined to the hornblende-lamprophyres of La Collette and Le Croc Point, and are present in such a small quantity relative to the basic and acid rocks that it is difficult to explain the chemistry' of the rocks in terms of crystal fractionation from an initial basic magma; similarly the trace-element distribution in the acid rocks would be difficult to obtain by such a process.

In view of the close temporal relationship between the emplacement of granite and of the dyke swarm, a more plausible explanation would involve the mixing of the incoming basic magma with the already emplaced granite. In this model, the material forming the acid dykes would represent not the end product of fractional crystallisation of basic magma, but granite magma remobilised from the host pluton at a fairly high level in the crust. The few intermediate rocks would be the product of mixing (by hybridisation or contamination) of the basic and acid end members. Such mixing would appear to have occurred only at an early stage in the history of the swarm to produce the leucocratic hornblende-lamprophyre of La Collette and the camptonite of Le Croc. Later mixing would seem to have taken place only locally, though acid and basic magmas continued to co-exist.

Authors and contributors

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