Drumadoon–Tormore

Highlights

Five major pitchstone dykes (Judd's Dykes') are excellently exposed in coastal outcrops. These dykes and other sills and sheets are exceptionally clear examples of composite (basic–acid) intrusions, where coexisting acid and basic magmas have interacted to produce hybrid rocks. Petrographic and chemical evidence indicates that the basic rocks were also hybridized before they were intruded.

Introduction

The coastal section between Drumadoon Point and Tormore provides good sections through a number of dykes and sills of quartz–feldspar porphyry, felsite and pitchstone. Many of these intrusions are composite and contain tholeiitic basaltic components. The 4-km-long shore section has two principal interests — the composite dykes in the King's Cave [NR 884 309] to Leacan Ruadh area [NR 887 322] and composite and acid sills at Drumadoon.

The composite dykes around Tormore were first systematically described by Judd (1893) in the now classic publication on these intrusions. Further work on these dykes and the sills at Tormore was carried out by the Survey (Tyrrell, 1928). McKerrow and Atkins's guide (1985) contains useful discussions on the origin of the Drumadoon intrusions, and a recent study on the hybridization and petrogenesis of the composite dykes, in particular the one at An Cumhann, has been published by Kanaris-Sotiriou and Gibb (1985).

Description

Five major composite dykes on the shore some 2 km south-west of Tormore, between Kings Cave and Leacan Ruadha, are commonly referred to as Judd's Dykes I–V (Figure 6.5). They are composed of quartz–feldspar porphyry, pitch-stones and tholeiitic dolerite intruded into Permo-Triassic sediments.

The dykes are exposed on the wave-cut platform and also in the raised beach cliffs where the pitchstone and felsite dykes and sills in the soft sediments are frequently highly devitrified and spherulitic.

At An Cumhann [NR 884 312], a 30-m-thick NNE-trending composite intrusion (Judd N) forms a low cliff (see Kanaris-Sotiriou and Gibb, 1985). It consists of quartz-feldspar porphyry flanked, and also intruded centrally by tholeiitic basalt which contains rounded xenocrysts of alkali feldspar and quartz. Locally, the basic rocks show marginal shearing and both components are cut by later, thin basaltic dykes and sheets. Bleached, indurated sandstones form a marginal ridge about a metre in width, a characteristic feature in all the intrusions of this section. An irregular hybrid zone occurs between the felsite and the basaltic members. To the north, the next dyke is Judd I, consisting of a central 5-m-wide greenish pitchstone with banded spherulitic felsite and tholeiitic margins. This dyke can be traced NNE for nearly 200 m along the shore and into the cliffs. Judd III is a 15 m wide, NW-trending dyke with a central 1–2-m-thick pitch-stone with an olivine dolerite in its northern edge. Judd III, which assumes a horizontal, almost sill-like, aspect in places, has provided many of the beautifully flow-banded, dark greyish-green pitchstone boulders found on the wave-cut platform hereabouts. Towards the north end of the section, nearer Tormore, Judd II is present as a 10 m thick quartz-phyric felsite dyke bordered by spheroidally weathered dolerite; Judd V is exposed nearby, being a conspicuous pitchstone dyke on the shore. Both Judd II and V trend east–west and cannot be traced far inland. The felsites contain phenocrysts identical to those in the pitchstones and are most probably their altered, devitrified equivalents. Fresh pitchstones contain phenocrysts of quartz, andesine, fer- roaugite, fayalitic olivine, hypersthene and Fe–Ti oxides. Running subparallel to this section, devitrified pitchstone and spherulitic felsite form at least two sills in the cliffs to the east and inland at Torr Righ Mor [NR 888 300], appearing at various levels due to minor faulting. The upper felsite is a continuation of the extensive Black-waterfoot Felsite to the south and is not cut by any basic dykes.

The composite quartz-feldspar porphyry and tholeiitic basalt sill at Drumadoon is situated at the south end of the site. This 25–30-m-thick sill forms The Doon [NR 885 293], a spectacular columnar feature (Figure 6.6) and extends southwest to Drumadoon Point, where the transgressive sill changes attitude to a more dyke-like form. The main part of the intrusion is formed by a quartz–feldspar porphyry with conspicuous feldspars up to 20 mm long, and smaller, glassy quartz crystals set in a pale felsitic matrix which becomes more basic next to the tholeiite margins. The lower part of the porphyry is sometimes crowded with rounded, lobate basic inclusions. The marginal tholeiitic sheets are 1–1.25 m thick and have sharply defined contacts with the acid component. Both the lower tholeiite and the rather poorly exposed upper tholeiite contain conspicuous quartz and alkali-feldspar xenocrysts, as do the lobate basic inclusions in the porphyry member.

About 400 m NNW of the northern end of Drumadoon, the small headland of Cleithadh nan Sgarbh consists of a thick porphyritic felsite with prominent flow-banding, a composite quartz porphyry–dolerite sheet and a later, cross-cutting tholeiitic dyke. Xenocryst-bearing dolerite at the edge of the composite intrusion intrudes the flow-banded porphyritic felsite. Within the composite intrusion there is a thin zone of acid hybrid developed between the basic margin and the porphyry; the latter carries xenocryst-bearing, rounded and lobate basic xenoliths. The composite intrusion has virtually the same petrological characteristics as Judd N at An Cumhann and may be its southerly extension (see Kanaris-Sotiriou and Gibb, 1985). It can be traced southeastwards into sea cliffs at the edge of the raised beach and may link with the porphyritic felsite exposed on the beach south of Blackwaterfoot golf course, about 400 m east of Drumadoon Point. The xenocryst-free dolerite dyke is a multiple intrusion cutting the composite sheet and the flow-banded felsite. The dyke splits into several sheets in the felsite where it appears to have caused localized melting of the acid rock.

Minor intrusions fail to cut the (presumably later) flow-banded felsite at Cleitheadh nan Sgarbh and are absent within the felsite sheets in the raised beach cliffs. However, the numerous basic dykes observed in this section cut sediments and composite intrusions alike.

Interpretation

The Drumadoon to Tormore coastal section b. provides classic, well-exposed and easily accessible examples of the composite acid–basic intrusions which commonly occur on Arran. The importance of the site has been realized since the early studies of Judd (1893) and, as a consequence, the section is frequently visited and has unfortunately suffered heavy damage through indiscriminate hammering of the attractive glassy pitchstones. The site clearly demonstrates that acid and basic magmas existed in this area at the same time, an important feature frequently noted in the BTVP (for example, Skye and Mull). A model for the petrogenesis of the composite intrusions in this area based upon a study of the dyke at An Cumhann, a possible feeder to the Drumadoon Sill, has been proposed by Kanaris-Sotiriou and Gibb (1985):

1. A differentiated, partially crystallized body of acid magma, bearing quartz, alkali feldspar and plagioclase phenocrysts existed at depth in the area.
2. Rising basic magma encountered the acid magma and passed through while generally retaining its identity; mixing was inhibited by the contrasting viscosity, composition and temperature properties of the two magmas. The basic magma, however, was partly hybridized by the incorporation of matrix and phenocrysts from the acid magma as xenocrysts.
3. The basic hybrid magma rose to higher levels and intruded Triassic sediments as dykes and sills of dolerite. Xenocrysts (especially alkali feldspar) were resorbed. Flow differentiation in the dykes/sills resulted in the concentration of xenocrysts towards the centre.
4. Acid magma was subsequently emplaced along planes of weakness into the unconsolidated centres of the hybrid basic dykes/sills. Contamination of the acid porphyritic magma occurred at the contacts with the dolerite, by *in situ* assimilation of the basic rock and the incorporation of the basic rock as xenoliths.
5. The acid magma continued to fill the centres of the intrusion and became progressively more acidic as more evolved magma was tapped from the reservoir.

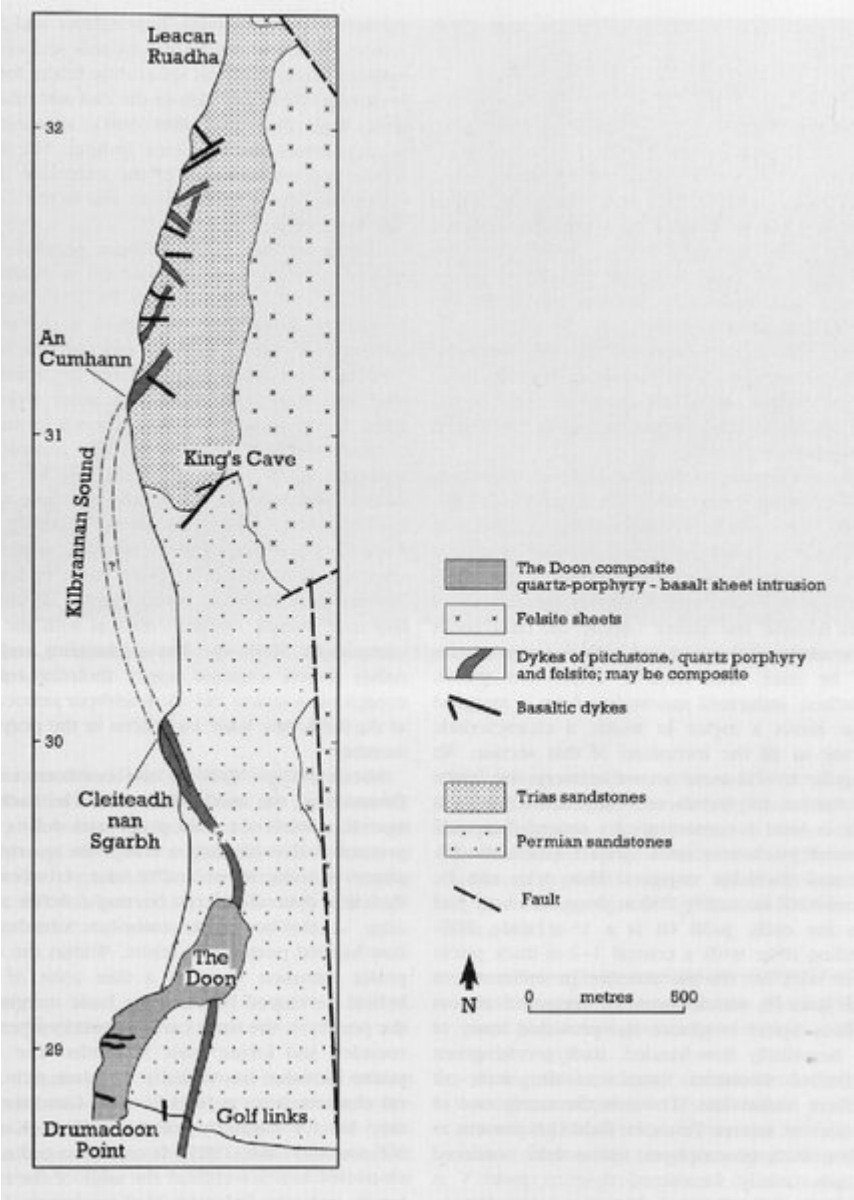
Kanaris-Sotiriou and Gibb (1985) suggested that all of the composite intrusions in this area formed in this way and all are related to a common source. They point out that composite sheets with cores of quartz–feldspar porphyry and dolerite

margins are also developed in the immediate vicinity of other major granite bodies in the BTVP and cite Skye and the Mourne Mountains as examples. The inescapable conclusion seems to be that the composite sheets are formed by a single fundamental mechanism rather than by the chance association of partly crystallized acid magma and basalt magma. They do not consider that the acid magma was derived from the basic magma by differentiation. Possibly it was generated by remelting, or partial melting, of an earlier Tertiary granite.

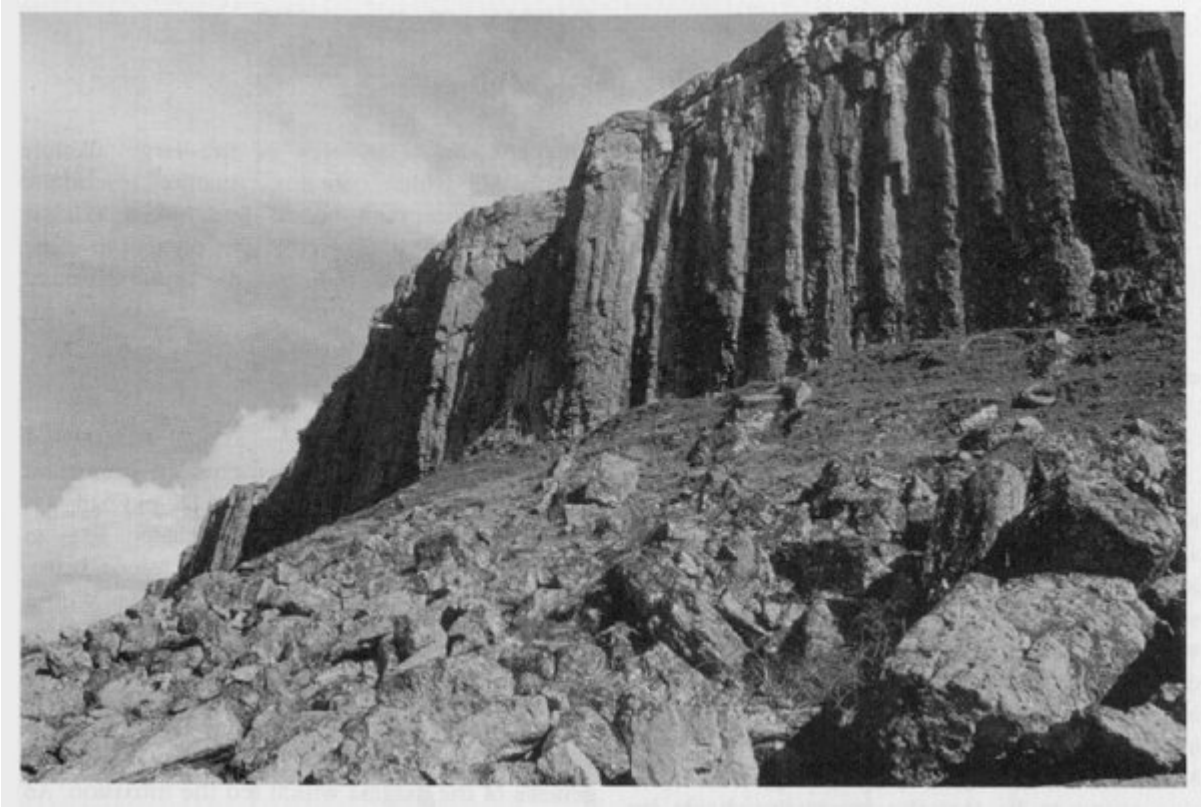
Conclusions

The site contains excellent examples of glassy, flow-banded pitchstones some of which form the central parts of composite acid–basic dykes. The composite dykes, sheets and sills provide clear evidence that basaltic and granitic liquids were in existence at the same time in this area and were intruded in quick succession (basaltic magma, followed by acid magma). The crystals found as phenocrysts in the pitchstones, and particularly in the quartz–feldspar porphyries, are also present as xenocrysts in the enclosing, earlier dolerites. This indicates that the basalt magma mingled with partially crystallized acid magma before it was intruded; the basaltic and doleritic margins thus have some of the features of hybrid (mixed magma) rocks.

References



(Figure 6.5) Geological map of the Drumadoon—Tormore site (adapted from the British Geological Survey 1:50 000 Special District Sheet, Arran, with additional information from McKerrow and Atkins, 1985, figure I la).



(Figure 6.6) Columnar jointing in the composite sill, The Doon. Drumadoon—Tormore site, Arran. (Photo: A.P. McKirdy.)