GEOLOGICAL RESEARCH IN SOUTH BUTE

by

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INTRODUCTION

South Bute has been the subject of geological research for the past one hundred and fifty years or so.

The first more or less detailed account of the area was by Macculoch (1819). Bouè (1820) suggested that the Garroch Head region was an island at one time. Bryce (1872) mentioned researches on the island's coast terraces and raised beach shelly deposits. He described the Kilchattan limestone in some detail and provided chemical analyses of it. He also supplemented to some degree the account of the dykes of Bute given by Macculoch and described the Arctic shell beds of Kilchattan.

Following Bryce, several papers on the Post-Tertiary beds of Kilchattan appeared, the most complete account being that of Brady, Crosskey and Robertson (1874). Gunn (1903) has given an accurate account of the geology of South Bute, including petrographic descriptions. Smellie (1913) described the Tertiary composite sill in the southern end of the island.

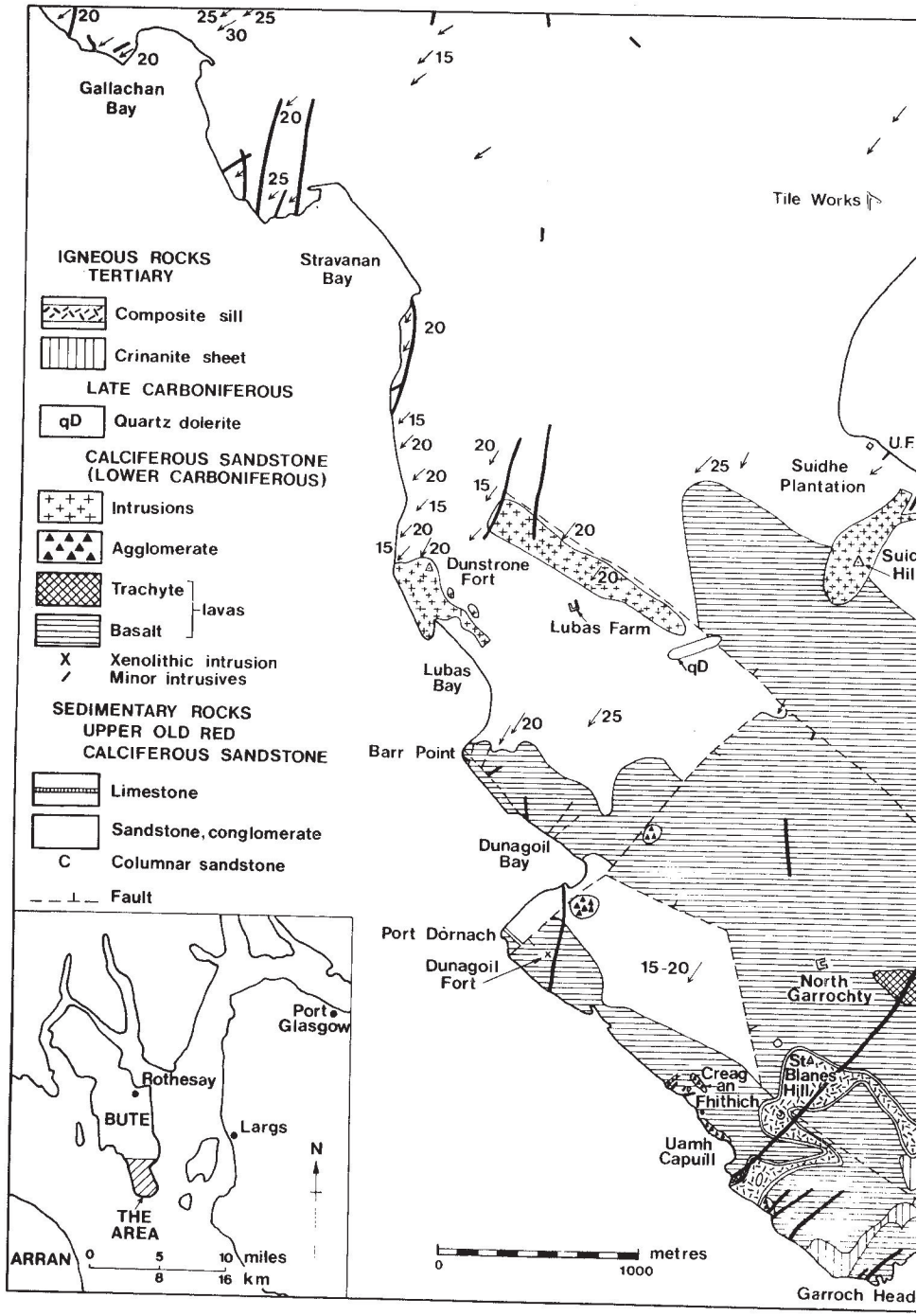
The most complete account of the igneous geology of the island is that of Smellie (1916). The olivine-basalt lavas are described for the first time in the light of the then new classification into macroporphyritic and microporphyritic groups. Smellie gives the first account of a remarkable intrusion (sill or sheet) containing ultrabasic xenoliths, located south of Hawk's Nib, and also three analyses of lavas.

Brown (1931) studied the dykes and associated intrusion of the area. McCallien (1938a, b) describes the geology of of the area. This author (1940) discusses mainly the large crinanite sheet in the south part of the area, to which he correctly assigns a Tertiary age, and to the Tertiary dykes and the composite sill which crosses the south part of the area in a general east to west direction from Roinn Clumhach to Uamh Capuill. He suggests a separate South Bute focus of Tertiary igneous activity, located to the south of the island. In Macgregor and Macgregor (1948), the occurrence of the three flows of trachyte, the presence of basaltic tuff and the

three sills of Markle basalt in South Bute are mentioned (as previously noted by Smellie in his 1916 account).

The economic possibilities of the limestone at the lower reservoir, Kilchattan, are given in Robertson et al (1949) entitled "The Limestones of Scotland." Buist (1952) describes the composite sill of South Bute, which is composed of five sheets, namely a thick middle dolerite flanked by sheets of quartz-feldspar-porphyry which in turn are ensheathed by an upper and lower dolerite. A hypothetical mechanism is suggested to account for the emplacement of the acid members of the sill between the upper and middle dolerites and between the lower and middle dolerites. A modification of this mechanism suggests how acid magma obtains access to a basic intrusion, this being the relationship found in most Tertiary composite sills and dykes. Buist (1953) gives a detailed account of the superficial deposits, sedimentary and igneous rocks of Bute. Matheson (unpublished work, 1962) has given a detailed description of the geology of South Bute, especially of the igneous rocks. Buist (1976; 1980, to be published) has provided accounts of a columnar sandstone at Kilchattan. Buist et al. (1979) reported age determinations on the composite sill and associated olivine-dolerite. They are both of Tertiary age and almost certainly belong to the 'Major Phase' of igneous activity occurring 59 million years ago. Hill (1979) has provided an excellent introduction to the geology and scenery of Bute, with several descriptive itineraries to localities in South Bute where interesting geological and topographical features are displayed. Mitchell et al. (1980, to be published) will describe a basaltic sheet with xenoliths, located on the shore 250 m south of Hawk's Nib, South Bute. The age of the intrusion is 309 +/— 5 million years old, which places it in pre-Middle Carboniferous times. It was first described by Smellie (1916) and also by Leitch (1919). The contained xenoliths, which are mainly of ultrabasic type (dunite, lherzolite, serpentine, augite-peridotite, olivine-pyroxenite, pyroxenite and anorthosite) appear to vary considerably in age, though there are problems in obtaining fresh samples due to the fact that alteration has occurred in the intrusion's passage through the country rocks, which are highly calcareous.

Figure 1 is an up-to-date geological map of South Bute,



based on the author's researches (since 1948) and checked by reference to the excellent aerial photograph coverage. It is worthy to comment at this stage regarding the high accuracy of Gunn's (1903) mapping.

ASPECTS OF THE GEOLOGY OF SOUTH BUTE OF SPECIAL INTEREST

As previously noted, South Bute is of great geological interest in that it contains a variety of rock types, including an absolutely unique five-component symmetrical Tertiary composite sill, over two miles in length; a remarkable columnar sandstone (also unique, as far as can be made out from a study of the literature) and a Carboniferous basaltic sheet containing ultrabasic xenoliths. These three examples will be discussed in some detail below:

(a) Composite Sill and Associated Olivine-Dolerite Sheet

Smellie (1913) described the composite sill as being composed of five members: a thick middle dolerite flanked by upper and lower quartz-feldspar porphyry, in turn ensheathed by upper and lower dolerites. He believed the basic rocks to be parts of a single injection which was followed by injections of acid magma along 'belts of weakness' between the massive marginal dolerites and the jointed middle dolerite. Buist (1952) gave reasons for inferring that the marginal sheets of dolerite were formed by a first surge of basic magma and the middle dolerite by a later surge i.e. the sill can be regarded as a composite multiple sill. The dolerites were contaminated by the acid magma prior to emplacement and the latter carries xenoliths of dolerite picked up during its intrusion. Smellie's estimate of the proportion of quartz-porphyry (27 per cent) contained in the marginal dolerite was confirmed by chemical analyses. It was shown that the uncontaminated basic rock would have a composition comparable with that of crinanite. A hypothetical mechanism was suggested to account for the emplacement of the acid members of the sill between the upper and middle dolorites and between the lower and middle dolorites. A modification of this mechanism suggested how acid magma would obtain access to the interior of a basic intrusion, this being the relationship found in most Tertiary composite sills and dykes.

Radiometric potassium-argon dating has been carried out on three members of the composite sill from Roinn Clumhach (Buist et al., 1979). The intrusion is undoubtedly Tertiary, with ages as follows:

Member	*Age (million years)*
Upper porphyry (centre)	56.3 (+/— 1.0)
Middle dolerite (centre)	48.2 (+/— 1.1)
Lower porphyry (centre)	51.1 (+/— 1.0)

The sheet which is intimately associated with the composite sill (Figure 1) is here referred to as a crinanite—it is in fact an ophitic olivine dolerite with crinanitic affinities in that the rock contains minor analcite in places. The sheet is first observed about 370 m north of Rudh' Nan Eun point, where its thickness is about 6 m. It crosses the Rudh' Nan Eun lava block in an approximately westerly direction to Glen Callum, where it is displaced by the large strike fault. The intrusion thickens on the other side of the fault and rises up to Torr Mor, where its direction changes to the south. About 200 m south of the latter it is cut by the composite sill. On the south side of this, the crinanite sheet occupies a relatively large area almost up to the Port Uisg fault. On the south side of the latter, the intrusion forms a well-marked feature on the raised beach. It terminates near Garroch Head. Over much of its outcrop, the crinanite sheet exhibits a characteristic deep coarse weathering.

There has been some controversy regarding its age, but Mitchell (in Buist et al., 1979) has determined this as being 50.3 +/— 1.4 million years. It is therefore Tertiary.

(b) Columnar Sandstone, Kilchattan

This thermally metamorphosed Upper Old Red sandstone Buist 1976; Buist 1980 is exposed on the shore and in the cliff behind approximately 350 m south-east of Kilchattan Pier (shown at 'C' in Figure 1). The generally constant alignment and size of columns make the shore outcrop a striking feature. The columnar structure probably developed as a result of emplacement of a basic dyke via a fissure — remnants of a highly altered dyke, only visible at low water, and identifiable in thin-section as a ferruginous basalt, occur in a 'gap' in the shore exposure. In view of the relatively large area exhibiting this columnar structure, metamorphic effects must have been amplified by the agency of steam and volatile constituents of the magma, passing up through the fissure.

(c) Intrusion containing Ultrabasic Xenoliths, Hawk's Nib

This intrusive sheet, measuring as it does only 50 m x 20 m, is unusual, possibly unique, in that it contains such a varied assemblage of xenoliths, mainly of ultrabasic type, in a small area. The sheet itself is an olivine basalt. Radiometric (potassium-argon) dating of the fresh rock has indicated that its age, 309 +/— 5 million years is pre-Middle Carboniferous. Three ultrabasic xenoliths were also dated, but showed such wide variation (approximately 250, 1000 and 2000 million years) that no simple interpretation of the ages is possible. One of the problems in dealing with the intrusion (and xenoliths) is that it has suffered extensive calcification in its passage through the Calciferous Sandstone sediments, which include such types as limestone and 'cornstone'.

FUTURE GEOLOGICAL RESEARCH IN SOUTH BUTE

Despite the significant amount of geological research which has been conducted in this southern portion of Bute, there still remain a number of topics which are capable of further study. These are:

(a) The detailed petrology and sedimentology of the Upper Old Red and Calciferous Sandstone (Lower Carboniferous) sediments.

(b) The petrochemistry of the Lower Carboniferous extrusive basaltic igneous rocks, grouped petrologically by Smellie (1916) into macroporphyritic and microprophyritic groups, a classification also employed by Buist (1953). It would be desirable to re-examine the South Bute rocks and re-assign the various types in terms of the system presented by Macdonald (1975) for the Early Carboniferous (Dinantian) lavas of Central and Southern Scotland. The latter is essentially a chemical classification and uses such rock names

as hawaiite and ankaramite.

(c) About 1200 m east of Dunstrone Fort (Figure 1), there is a small intrusion of quartz-dolerite, probably a dyke, which may be Late-Carboniferous in age. It would also be of interest to have an accurate dating of this, also data on its chemistry and mineralogy.

(d) A more detailed examination of the dykes of South Bute (following Brown, 1931 and Buist 1953) would be of great interest from the mineralogical and petrochemical points of view.

SUMMARY AND CONCLUSIONS

A review of past geological research in South Bute has been given, also topics for future study. From this point of view, the area is a very fruitful one. For its size, especially with the presence of three unique bodies, it can be stated that South Bute contains some of the most interesting assemblages of rocks in the world.

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