Chapter 12 Old Red Sandstone of Foula

Introduction

Foula is a pear-shaped island, 3.5 miles (5.6 km) long from north to south and 2.5 miles (4 km) wide from west to east (Figure 21). It is situated in the Atlantic Ocean 14 miles (22 km) WSW of Wats Ness in the Walls Peninsula and has a prominent skyline, which, when viewed from the mainland, presents three steep north-facing escarpments with relatively gentle south-facing dip slopes. The most northerly escarpment forms Soberlie Hill, 721 ft (220 m) high; the central one has three peaks which are, from west to east, The Kame (1220 ft, 372 m), The Sneug (1373 ft, 406 m) and Hamnafjeld (1126 ft, 343 m). To the south of these the island is traversed by a west-north-west trending glacially moulded valley, known as The Daal. South of this lies The Noup (803 ft, 245 m), a hill which has a less prominent north-facing escarpment than the others.

The greater part of Foula is formed of relatively soft sandstone with subordinate shale and siltstone bands. This sedimentary series appears to be of Middle or Upper Old Red Sandstone age and has a total exposed thickness of about 6000 ft (1800 m). The sandstone forms prominent vertical cliffs all along the west coast of the island. These have a maximum height of 1220 ft (372 m) at The Kame, which forms one of the highest sea-cliffs in the British Isles.

The Old Red Sandstone sediments are bounded in the east by a 0.5 mile (800-m) wide strip of metamorphic rocks and the two formations are separated from each other by a slightly curving north-north-west trending fault. At its outcrop on the north coast this fault is inclined at 60° to the west, but at its southern coastal outcrop it is inclined at only 35° to the south-west.

Owing to its unique position and prominent topography Foula attracted many of the early geological investigators who visited the northern isles. There are accounts of the topography and geology of Foula by Jameson (1798), Hibbert (1822), Nicol (1844) and Gibson (1877). The first comprehensive geological account of Foula is by Heddle (1878, pp. 124–30). More recent accounts dealing with the geology of Foula are by Peach and Horne (*in* Tudor 1883, p. 395), Finlay (1926, pp. 564–5), and Wilson (*in Summ. Prog. geol. Surv.* 1934, pp. 71–3).

Field relationships

The Old Red Sandstone of Foula consists of approximately 6000 ft (1800 m) of relatively soft, predominantly medium-grained, grey to buff sandstone, with small isolated pebbles of quartz and granite and with a number of partly or predominantly argillaceous or silty horizons. Many of the sandstones are cross-bedded with a consistent dip of foresets towards the east to south-east sector. The structure is simple, consisting of a very open, southward plunging syncline. Close to the fault which separates the sediments from the metamorphic rocks to the east, the dip of the strata is locally much steeper and the strike is roughly parallel to the fault.

Though the sediments of Foula display a remarkable uniformity throughout their thickness, it is possible to recognize the following nine more or less distinct members (Figure 21):

	feet	metres

9	Noup Sandstone	Yellow, medium-grained, cross-bedded sandstone, in sets up to 6 ft (1 -8 m) thick, with dips of foresets predominantly to east-north-east. Scattered small rounded quartzite pebbles are present throughout, with some lenses containing pebbles up to 2.5 in (6 cm) in diameter	800+	240+
8	Daal Flaggy Sandstone	Cross-bedded sandstone with scattered pebbles interbedded with yellow-weathering flaggy sandstone and a few beds, up to 18 in (45 cm) thick, of greenish grey sandy siltstone. Disseminated indeterminate plant scraps occur in silty and flaggy beds at Biggings (south coast) and Surpeidles (south-east coast). Dip of foresets is mainly to east	500	150
7	Wester Hoevdi Sandstone	Predominantly massive medium-grained cross-bedded sandstone, with very thick sets and few flaggy partings. Scattered small rounded pebbles of quartzite, quartz and granite	1600	490
6	Kame Banded Beds	Buff, greenish, purplish and brownish evenly bedded, mainly flaggy sandstones with fairly thick shaly and silty partings	520	160

5	Kame Argillaceous Beds	Grey and purplish silty shale and siltstone with subordinate sandstone ribs. Indeterminate plant fragments in siltstone and shale are found at North Bank, 1770 yd (1620 m) NE of The Kame, in Blobers Burn 300 yd (275 m) WNW of Harrier, and in a roadside quarry, 250 yd (230 m) ENE of Harrier	120	35
4	Soberlie Hill Sandstone	Sandstone, medium-grained, ochre-yellow-weathering, in cross-bedded sets up to 2 ft (60 cm) thick with small scattered pebbles up to 3 in (8 cm) in diameter throughout. Some gritty beds with abundant rounded pebbles are present near the base. Dip of foresets is predominantly to east-south-east. Flaggy and silty partings are very rare	1400	400

3	East Hoevdi Beds	Alternate thick cosets of (a) medium-grained cross-bedded sandstone ranging in thickness from 10 to 80 ft (3–25 m) and (b) thinly interbedded and interlaminated grey and purplish flaggy sandstones, siltstones and shales up to 60 ft (18 m) thick. Contorted and slumped bedding is common in the thicker cross-bedded sets. Dips of foresets to SE–ESE sector. Sand-filled desiccation polygons are present in mudstones; and mudstone chips occur in some of the intercalated sandstone sets. Base of group is predominantly sandy	450	140
2	Ness Beds	Sets of thinly bedded buff cross-stratified sandstone up to 4 ft (1.2 m) thick, commonly with pellets and chips of purple mudstone and some red shale partings alternating with sets of grey and purple mudstone, silty mudstone and siltstone 4 in to 4 ft (10 cm-1.2 m) thick, with sand-filled desiccation polygons. Sandstone fillings of cracks are commonly distorted, and irregular convolute pseudonodules of sandstone are present in the adjoining mudstone (Figure 22)	100	30
1	Gaada Stack Sandstone	Predominantly massive, yellowish-buff-weathering sandstone	250+	75+

These nine groups have been mapped along the west coast and through the centre of the island. Though small isolated rounded pebbles are present in the cross-bedded sandstones throughout the sequence lenses of extraformational conglomerate with abundant large pebbles are absent. The pebbles appear to be of uniform composition throughout and consist of white, yellow and amber-coloured quartz, quartzite and, rarer, red granite. The smallest pebbles are, in many instances, microcline.

On the east coast of Foula just south of the junction with the metamorphic rocks at Shoabill, there is a banded group of sediments, which presents some features not found in any of the argillaceous or banded groups enumerated above. The lower 60 ft (18 m) of this group consist of alternate sets of siltstone, up to 4 ft (1.2 m) thick, and medium-grained sandstone. The siltstones are reddish brown or pale green in colour and contain thin laminae and pseudo-nodules of fine-grained sandstone. Desiccation cracks and polygons are abundant and individual polygons are up to 2 ft (60 cm) in diameter. The sandstone infillings are up to 3 in (7.6 cm) thick. Several of the sandstone posts contain mudstone 'chips' which are the cracked and dried-up remains of thin layers of mud. A bed of sandy siltstone at the top of this alternating sequence contains a 3-ft (90-cm) thick band, which exhibits intensely convolute and slumped lamination. This contains recumbent 'slump balls' which are up to 1 ft 6 in (45 cm) thick, and have their convex side facing south-east, suggesting that their shape was to some extent determined by lateral slipping of unconsolidated material towards the north-west, which is contrary to the prevailing direction of current movement elsewhere on the island. The slump-bedded horizon is overlain by up to 40 ft (12 m) of buff-weathering medium-grained sandstone with partings, up to 18 in (45 cm) thick, of greenish grey siltstone. This is, in turn, succeeded by 20 ft (6 m) of massive greyish green unlaminated poorly graded clayey sandstone full of angular clasts of sediment up to 1 in (2.5 cm) long, but in some instances reaching a length of 8 in (20 cm). The clasts consist principally of siltstone and mudstone and the entire bed has the characteristics of a mudflow conglomerate (*see* Bluck 1967, p. 144).

The junction between the sedimentary and metamorphic rocks at Shoabill has been shown as a fault on the one-inch and six-inch geological maps. The actual junction is a well-defined shear-plane inclined at 35° to the south-west and underlain by up to 6 ft (1.8 m) of sheared metamorphic rock. It is, however, overlain by up to 10 ft (3 m) of sheared 'conglomerate' which contains sub-rounded pebbles and blocks of gneiss. The latter are up to 2 ft 6 in (75 cm) in diameter and are set in a matrix of sheared gneissose material. It is not certain if this rock is a true conglomerate or if the partial rounding of its clasts is entirely due to shearing. The author favours the latter interpretation. The upper junction of the 'conglomerate' is undulating, but sharply defined and cut by a number of small faults. It is overlain by hard, slightly reddish medium-grained sandstone, which contains, just above its base, a 1 ft 6 in to 3 ft (45–90 cm) thick concordant sill-like mass of brittle, fine-grained yellowish rock, which in the field resembles a felsite, but is in thin section seen to be an intensely sheared sandstone. The junction between metamorphic rocks and sediments in this area is without doubt a faulted one, but if the 'conglomerate' described above is of sedimentary origin and is not a true fault breccia as the author believes the present junction must be close to the original unconformity between the two groups. If that were the case the subsequent fault movement would here appear to have been more or less along the unconformable junction.

Conditions of deposition

The greater part of the Foula succession appears to be composed of fluvial sandstones laid down by relatively fast-flowing, possibly braided, rivers. The lower part of the sequence was probably deposited by currents from the west to north-west sector, and the upper part by currents from the west or south-west. The presence of red and purple siltstones and mudstones with sand-filled desiccation cracks in the lower half of the sequence, well seen on the north and east coasts of the island, suggests that there were some periods with a quieter fluvial regime, possibly dominated by meandering rivers with flood plains on which top stratum deposits were preserved. The uniform composition of the sandstones (p. 176) and their scattered pebbles (p. 174) throughout the sequence suggests that the source area remained much the same during the entire period.

Petrography

The medium- to coarse-grained pebbly sandstones of Foula are generally bi-modal with scattered well-rounded pebbles, 3 to 1 cm in diameter, set in a well-graded arkose or feldspathic sandstone (cf. Pettijohn 1957, p. 291). The latter is

composed of subrounded to subangular grains commonly ranging in diameter from about 0.75 to 0.1 mm ((Plate 8), fig. 6). The quartz-feldspar ratio varies from 50:50 in the coarsest sandstones to 70:30 in the fine-grained sandstones. Quartz grains are generally more rounded than feldspars, which consist of both untwinned potash feldspar and rarer microcline, as well as sodic plagioclase. Though the feldspar grains are, in some instances, patchily seticitised or kaolinitized, they are commonly fresh. Other grains consist of felsite, and more rarely, fine-grained sediments such as siltstone and clayey limestone. There are also small grains of apatite, zircon and tourmaline and small rounded grains of opaque ore minerals. Both muscovite and biotite, in some cases mantled by chlorite or partially altered to chlorite, are present in all sections and form up to 20 per cent of the total volume in the flaggy partings. The detrital matrix composed of an aggregate of clay minerals and chlorite normally forms less than 5 per cent of the total volume. In some sandstones of all grain sizes, however, a calcareous cement forms up to 15 per cent of the rock and has patchily replaced the feldspar grains.

The fine-grained flaggy sandstones normally have grains ranging from 0.5 to 0.08 mm in diameter and have a considerably higher quartz-feldspar ratio (70:30 to 80:20) than the medium-grained sandstones, as well as a higher proportion of partially chloritized mica flakes. The dark grey ungraded sandstone with scattered pebbles of sediment, exposed on the shore south of Shoabill, close to the junction with the metamorphic rocks (p. 174), is unique in Foula. It consists of widely scattered subangular to subrounded grains of quartz and feldspar (quartz-feldspar ratio 9:1) together with subrounded fragments of siltstone and clayey limestone which range in size from over 5 to 0.03 mm, as well as some grains of felsite and tourmaline. The matrix forms over 25 per cent of total volume of the rock and is composed of a matted mass of mica flakes set in an indeterminate brownish aggregate. This highly ungraded immature sediment contrasts strongly with the generally well-graded sandstones of Foula.

Structure

The sedimentary rocks of Foula form an open syncline plunging at 20° to 30° to the south. The eastern limb of this syncline steepens appreciably close to the eastern boundary fault and the strike of the beds in a 109 yd (100 m) wide zone bounding the junction is roughly parallel to this fault. In the exposures along the north shore where the fault is inclined at 70° to W10°S, the adjoining sediments are intensely shattered and cut by a number of small faults which trend N60°W and range in inclination from 60° to 85° to the south-west, as well as by several faults which are sub-parallel to the main fault.

Apart from the faults associated with the eastern boundary fault the Foula sediments are relatively free from major faulting. Two north–south trending faults with small throws and westward inclinations cut the north coast at Trolli Geo and a small geo 150 yd (135 m) farther east. These have small downthrows to the west and both appear to die out southwards.

The sediments throughout the island are cut by several systems of closely spaced faults with very small displacements. These are well seen on the large expanses of bare bedding planes such as those forming the south-east side of Logat Stacks. On the latter three intersecting sets of minor faults and joints are developed. These are :

1. Strike faults, trending E25°S, spaced 10 to 15 yd (9–14 m) apart with small downthrows (1 to 3 ft, 0.3–0.9 m) to the south-south-west.
2. Very small faults trending E30°N with very small downslip to south-south-east.
3. Small faults trending N22°E, about 25 yd (23 m) apart with small displacement to east-south-east.

Intense jointing and possible small-scale faulting is also well seen on the shores of South Ness, where the dominant trend is N10°W. On the hill slope north-east of the Wick of Mucklaberg the intersection of the south-south-west dipping bedding planes in the Daal Flaggy Sandstone, which are parallel to the steep undercut hillside, with west-north-west trending joints provides conditions ideal for landslides. The Smallie, a deep cleft over 250 yd (230 m) long and 6 ft (1.8 m) wide and as much as 100 ft (30 m) deep (Heddle 1878, p. 128) is the most prominent of a series of joints which have been opened by the down-dip slipping of the sandstone to the south.

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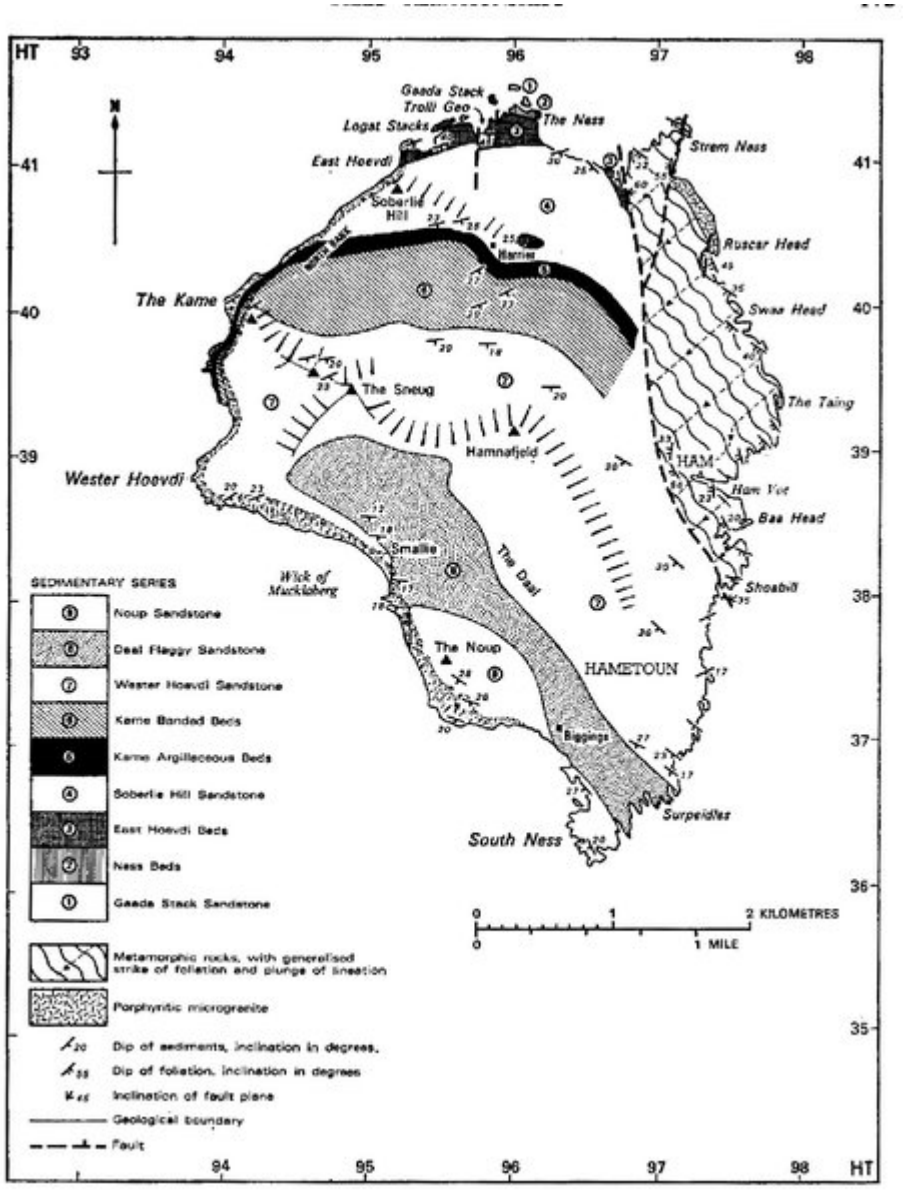
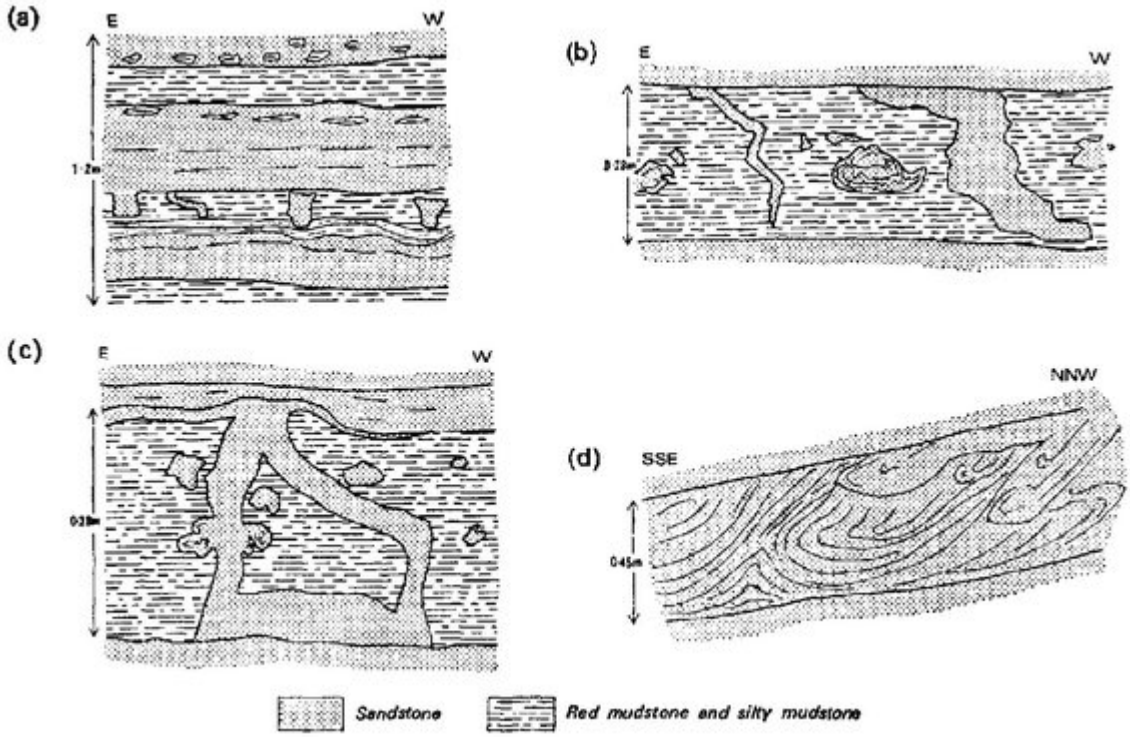
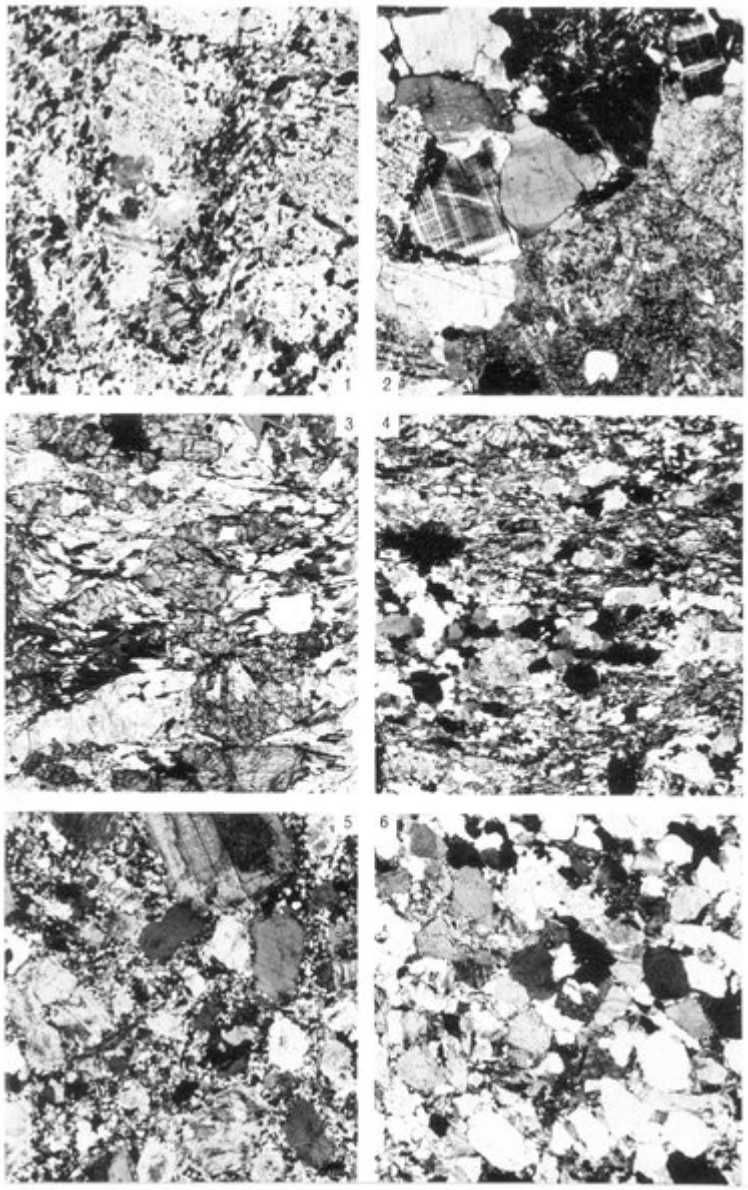


(Figure 21) Geological sketch-map of Foula.



(Figure 22) Sedimentary structures in the Old Red Sandstone sediments of Foula a. North shore, opposite The Brough [HU 961 416]. Buff sandstone interbedded with red mudstone, with sand filled desiccation cracks in mudstone and mudstone chips in sandstone. (b)and (c) Locality as in (a). Distorted sandstone 'dykes' and slump-balls in red silty shale. (d) East shore, South Ness, 270 yd (250 in) SSW of Shoabill [HU 974 379]. Convolute bedding in sandstone.



(Plate 8) Photomicrographs of metamorphic rocks, microgranite and sandstone of Ve Skerries and Foula Fig. 1. Slice No. (S29982) [HU 103 658]. Magnification × 16.8. Crossed polarisers. Granulitized granite with large crystals of albite-oligoclase, sieved with muscovite. Adjacent feldspar crystals are in optical continuity and separated by streaked out mozaic-quartz. Small near-euhedral crystals of epidote are abundant in the quartz network. Ve Skerries, North Skerry, west coast [HU 103 658]. Fig. 2. Slice No. (S29989) [HU 104 656]. Magnification × 31. Crossed polarisers. Coarse poorly-foliated granite-gneiss composed of quartz, large clear plates of potash-feldspar and albite-oligoclase full of inclusions of white mica, and small grains of epidote. Ve Skerries, Ormal, north coast [HU 105 656]. Fig. 3. Slice No. (S29898) [HT 975 401]. Magnification × 8. Plane polarized light. Garnet-kyanite-staurolite-gneiss, with muscovite and quartz. Large stumpy plates of kyanite with close parallel cleavage (bottom and top centre), smaller plates of golden-yellow staurolite, and subrounded garnets are set in a base of biotite, muscovite, quartz and andesine. Foula, Swaa Head, 860 yd (790 m) NNE of Sloag. [HU 976 401]. Fig. 4. Slice No. (S50823) [HT 973 388]. Magnification × 20. Plane polarized light. Strongly foliated and sheared quartz-biotite-schist composed of lenses of quartz with mortar texture alternating with streaks composed of feldspar, muscovite and reddish brown biotite. Scattered porphyroblasts of oligoclase (left-centre). Foula, south shore of Ham Voe, 110 yd (100 m) E5°N of Brae [HU 974 387]. Fig. 5. Slice No. (S29900) [HT 975 401]. Magnification × 16. Crossed polarisers. Dyke of porphyritic microgranite, with granulitized matrix between phenocrysts of albite-oligoclase. Foula, Swaa Head, 880 yd (800 m) NNE of Sloag [HU 976 401]. Fig. 6. Slice No. (S50829) [HT 963 407]. Magnification × 16. Crossed polarisers. Coarse-grained arkose with subrounded to subangular grains. Ratio of quartz to feldspar grains is 50:50. Some interstitial flakes of muscovite. Matrix forms 15 per cent of total volume, composed mainly of carbonate. Foula, shore of Whiora Wick, 520 yd (470 m) E20°S of Freyars [HU 966 412].