Orkney and Shetland, summary of geology

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Shetland
Geological sketch-map of Shetland.
P915566.
The East Mainland Succession—(graphic representation of stratigraphic units).
P915570.
Geological map of Shetland east Mainland and some adjacent islands. P915596.
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Whitaloo Point, Birsay, north-west coast of Orkney Mainland. Narrow zone of folded fagstones (ruck). PP219013.

Shetland consists partly of ancient sedimentary rocks which were metamorphosed and intruded by igneous rocks during the Caledonian Orogeny, and partly of sedimentary and volcanic rocks of Old Red Sandstone (Devonian) age which were laid down and folded during the final phases of that orogeny. It forms a link between the Norwegian, Scottish and East Greenland portions of the Caledonian Orogenic Belt, as they were before disruption by Continental Drift. The understanding of the complex geology of Shetland is thus of considerable importance in any attempt to correlate any of these three remnants of the Caledonian mountain chain. Not only does it provide a link between the stratigraphic and structural units of the metamorphic rocks of the three areas, but it also augments our insight into the palaeogeography of this orogenic belt during Old Red Sandstone times.
and provides some data about the final localised phases of compression and magma emplacement.

Shetland is divided into two geologically distinct parts, henceforth termed West and East Shetland, by a major north—south trending fault which is termed the Walls Boundary Fault (P915566). It has been suggested that this is the northward continuation of the Great Glen Fault (Flinn 1961b) and like the latter it appears to be a transcurrent fault, in this case with a post-Devonian dextral displacement of 60 to 80 km.

**Metamorphic rocks**

**West Shetland**

Acid and hornblendic gneisses which may be of Precambrian (Lewisian) age form the north-west corner of the Northmaven peninsula and the Ve Skerries, a group of small skerries situated some 6 km NW of Papa Stour. These rocks (Metamorphic Group A in P915566) may be part of the Caledonian Foreland, separated from the metamorphic rocks of the Caledonian Orogenic Belt to the east by the northward continuation of the Moine Thrust.

East of the ‘Lewisian’ gneisses a belt of metasediments (Metamorphic Group B in P915566) extends from the northern tip of Mainland southwards along the Walls Boundary Fault to Muckle Roe. Two major rock groups are present in this belt. The older consists of thick steeply inclined bands of impure quartzite, hornblendic gneiss and muscovite-schist. The younger is generally finer-grained and contains two formations with distinctive lithologies: the Greenschist Group and the Calcareous Group. Another strip of metasediments crops out along the north side of the Walls Peninsula and on the islands adjoining this coast. The strike and foliation of the latter rocks is almost east-west and their overall inclination is to the south. They are made up of platy feldspathic muscovite-biotite-gneiss, together with hornblende-schist, tremolite-schist and some calc-silicate-rich limestones. It is probable that these rocks can be equated, at least in part, with the metasediments of Northmaven. The narrow strip of metamorphic rocks along the north-east shore of Foula is similar to the metasediments of the Walls Peninsula.

The metasediments of West Shetland are unlike any of the metamorphic rocks of East Shetland. A study of the deformation history of the rocks suggests that they have been involved in only one orogeny and the potassium-argon dates (435 to 400 m.y.) indicate that this is of Caledonian age; yet it has not been possible to equate them with any members of the Moine- Dalradian sequence of Scotland.

**East Shetland**

The area east of the Walls Boundary Fault is made up of metamorphic and plutonic rocks, which in the south-east of Mainland are unconformably overlain by Old Red Sandstone sediments. The metamorphic rocks have been grouped into the following three major tectonic units (P915566):

1. The East Mainland Succession.
2. The Quarff Succession.
3. The Unst–Fetlar Nappe Pile.
The **East Mainland Succession** consists of a thick series of north—south trending vertical or steeply dipping metasediments which probably forms a continuous stratigraphic sequence, with the oldest rocks in the west and the youngest in the east. The Succession may be between 22 and 27 km thick and can be split into four major divisions, ([P915566](#) and [P915570](#)). The most westerly (Yell Sound) division is composed of variably migmatised feldspathic psammites (i.e. metamorphosed sandstones), and has been tentatively correlated with the Moinian of the Scottish mainland. The next (Scatsta) division consists of quartzites, pelitic schists and gneisses, and the third (Whiteness) is made up of flaggy psammitic with four thick bands of limestone. The metasediments which form these two divisions are tentatively correlated with the Lower and Middle Dalradian of Scotland. The most easterly (Clift Hills) division consists largely of phyllite with bands of quartzose grit and contains some metamorphosed spilitic lavas. It has been tentatively equated with the Upper and possibly also part of the Middle Dalradian of Scotland (Flinn and others 1972, fig. 1)[2] and the Cambro-Ordovician of Norway (Miller and Flinn 1966)[3]. The East Mainland Succession contains two great belts of migmatitic gneiss and associated granitic and pegmatitic intrusions. The succession is also intruded by a number of plutonic complexes, which appear to be about 400 million years old.

The island of Yell is made up of a great thickness of migmatised pelites and semipelites with some thick bands of quartzite. These rocks have been tentatively correlated with the lowest (Yell Sound) division of the East Mainland Succession and, by implication, the Moinian of Scotland. The Lunnasting area of Mainland ([P915596](#)), together with Whalsay, the Out Skerries and the western parts of Unst and Fetlar, are composed of strongly migmatised metamorphic rocks which contain bands of hornblende-gneiss, calcareous schist and limestone. They have been correlated with the two middle divisions of the East Mainland Succession. In Unst and Fetlar these rocks have been locally affected by two phases of retrograde metamorphism, which have become well known through the classic work of H. H. Read (1934[4], 1937[5]).

Along part of the east coast of south Mainland the phyllites and spilites of the East Mainland Succession are in tectonic contact, through a mélange of shear-bounded slices, with a suite of permeation gneisses, semipelites and gritty limestones. Though most of these rocks are similar to some members of the East Mainland Succession they are considered to belong to a separate tectonic unit, which is termed the **Quarff Succession**.

The eastern half of Unst and the greater part of Fetlar consist of a number of large tectonic ‘blocks’ of serpentinite, metagabbro, and, in east Fetlar, a great thickness of deformed conglomerate. These ‘blocks’, collectively termed the **Unst–Fetlar Nappe Pile**, are separated from each other and from the metamorphic rocks to the west by thrust planes and schuppen-zones composed largely of phyllite, graphite-schist and greenschist. The whole area is thought to form part of two great nappes which were originally parts of an ultrabasic and basic intrusive complex. The schuppen-zone separating the two nappes contains pebbles and debris derived from the erosion of the lower and possibly also the upper nappe. This suggests that the nappes of this area were emplaced at a very high tectonic level, possibly by gravity sliding on the surface of the developing Caledonian mountain chain.

**Old Red Sandstone**

**West Shetland**

The Old Red Sandstone of West Shetland falls into two distinct groups which are separated from each other by the north-north-east trending Melby Fault. East of this fault is the immensely thick Lower to Middle Old Red Sandstone outcrop of the Walls Sandstone, which forms the greater part of the Walls Peninsula. This can be divided into two lithostratigraphical units, the Sandness Formation and the Walls Formation. The former includes the Clousta Volcanic Rocks near its top. Both
formations have been affected by two major episodes of folding, the first of which produced a complex east-north-east trending synclinorium and the second a number of tight north to north-east trending folds. There are also several small folded outliers of sandstone and breccia of possible Devonian age in North Roe and on the island of Gruney, 2 km N of the most northerly point of Mainland.

The Old Red Sandstone west of the Melby Fault is termed the Melby Formation. It contains two fish-bearing horizons, the Melby Fish Beds, which have been correlated with the Sandwick Fish Bed of Orkney. The sediments of the Melby Formation appear to be conformably overlain by basic lavas, tuffs and rhyolites which form the island of Papa Stour and the peninsula of Esha Ness in Northmaven.

The greater part of Foula consists of soft buff, gently inclined sandstones with subordinate siltstones and shales which have yielded plant remains of Devonian aspect.

**East Shetland**

The sedimentary rocks which crop out along the south-eastern coastal strip of Mainland and on the islands of Bressay and Noss rest unconformably on metamorphic rocks. The surface of unconformity appears to have a high relief and the base of the overlying succession is strongly diachronous. The sequence consists in part of sandstones with lenticular masses of conglomerate and basal breccia and, higher in the succession, of interbedded sandstones and flagstones. The fish remains suggest that the age of these beds is high Middle Devonian (Givetian) and that the highest beds may be equivalent to part of the Upper Old Red Sandstone of the Scottish mainland.

**Fair Isle**

This island consists of a thick sequence of medium-grained sandstone and pebbly sandstone with subsidiary bands of dolomitic mudstone and shale. Plant remains and fish fragments suggest that the age of the beds may range from Lower to Middle Old Red Sandstone.

**Late Caledonian intrusions**

The metamorphic and sedimentary rocks west of the Walls Boundary Fault have been intruded by a series of probably interconnected plutonic complexes composed mainly of granite, diorite and subordinate gabbro which, from radiometric studies, appear to be between 350 and 360 million years old. Great swarms of roughly north—south trending acid, intermediate and basic dykes cut the more northerly of these plutonic complexes and the adjoining country rocks. East of the Walls Boundary Fault the metamorphic rocks are cut by dykes and sills of microdiorite, many of which are slightly affected by shearing and thermal metamorphism, and also spessartite.

The Old Red Sandstone sediments of Bressay and Noss contain two north-south trending belts of steeply inclined strata which are associated with vents and with more irregular masses of non-igneous tuffisitic breccia and tuffisite.

**Orkney**
**Stratigraphy**

The Orkney Islands ([P915567](#)) consist almost entirely of sedimentary rocks and subordinate lavas and tuffs of Middle and Upper Old Red Sandstone age. A Basement Complex composed of metamorphic rocks of Moinian type and Caledonian granites forms a number of small inliers near Yesnaby and Stromness in West Mainland and on the island of Graemsay ([P915581](#)). At Yesnaby there is also a group of sandstones and breccias which may be of Lower Old Red Sandstone age, and at Warebeth, west of Stromness, purple siltstones and sandstones, possibly of similar age, have been encountered in a borehole.

The Middle Old Red Sandstone falls naturally into two major groups. The lower group, comprising the Stromness Flags and the Rousay Flags, consists largely of ‘flagstones’ and is made up of rhythmic sequences of thinly bedded and, in part, laminated grey and black carbonate-rich siltstones and silty mudstones alternating with generally thin beds of fine-grained sandstone or sandy siltstone. The flags have yielded well-preserved fossil fish and the Stromness Flags contain the Sandwick Fish Bed, which is considered to be the equivalent of the Achanarras Limestone of Caithness.

The upper group, the Eday Beds, comprises the Lower, Middle and Upper Eday Sandstone, three thick sequences of yellow and red sandstone with pebbly lenses, which are separated respectively by the Eday Flags and the Eday Marls. The Eday Flags locally contain a few thin flows of basic lava and some thin beds of tuff.

Beds ascribed to the Upper Old Red Sandstone are confined to the island of Hoy, where they form up to 1000 m of red, pink and yellow sandstones with subordinate bands of marl. They are underlain by a variable thickness of basalt lava and tuff which rest on a hummocky surface floored by various members of the Middle Old Red Sandstone sequence.

**Structure**

The outcrops of the major rock groups and the axial traces of the major folds of Orkney are shown in [P915567](#). Most folds affecting the Old Red Sandstone are very open so that the strata are generally gently inclined, but there are a few folds of limited regional extent which have steeply inclined limbs. Many of the principal folds have a near-northerly trend. The most important of these is the northward-plunging Eday Syncline which determines the structure and physiographic pattern of the northern group of islands. Other well-marked flexures of regional importance are the West Mainland Anticline and the Deerness Syncline. Of equal importance in determining the structural pattern of Orkney and the disposition of the various rock groups are the faults. The largest and most important of these are the North Scapa Fault, the East Scapa Fault and the Brims–Risa Fault ([P915567](#)). The latter two are reversed faults for at least part of their course. Smaller faults are numerous and closely spaced, but many of them have relatively small displacements. The faults can be divided into the following three systems according to their trend:

a. East-north-east to north-easterly, e.g. North Scapa Fault and major faults cutting Shapinsay and South Ronaldsay.
b. Northerly (i.e. with trends ranging from north-north-west to north-north-east), e.g. East Scapa Fault, faults in South Ronaldsay and Westray and a suite of sub-parallel step faults in West Mainland.

c. North-westerly. These are less common.

Adjacent faults generally have the same direction of downthrow. Movement on many faults began before the deposition of the Upper Old Red Sandstone and some, such as the North Scapa Fault, were probably active during and possibly even before the deposition of the Middle Old Red Sandstone Eday Beds, whose thickness appears to be greatly increased on their downthrow sides.

A characteristic feature of the flagstones of both Orkney and Caithness is the presence of narrow belts of intensely folded and contorted sediments. These belts generally have an overall monoclinal pattern (P219013) and a trend which is parallel to the dominant fault system of the area. Some of these tight monoclines contain belts of mineralised breccia.

**Minor intrusions and volcanic vents**

The earliest intrusive rocks cutting the Old Red Sandstone sediments of Orkney are small masses of teschenitic dolerite which are associated with the alkaline basic lavas and tuffs in the Eday Flags. Most of the dykes and sills of Orkney, however, belong to the suite of late-Carboniferous camptonites, monchiquites and bostonites and they are most numerous in the south and west of Orkney, with camptonites predominating in West Mainland and Rousay and monchiquites in the southern islands.

A number of small volcanic vents have been recorded, principally in Hoy, South Ronaldsay and East Mainland. Some of these are closely connected with monchiquite dykes and a few are partly filled with monchiquitic basalt. Several of the vents contain breccia composed entirely of sedimentary rock and these resemble the breccia vents of East Shetland.

**Bibliography**

[Full bibliography list]


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