
Chapter 5 Upper Jurassic stratigraphy in Scotland

Introduction

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Outcrops of Oxfordian and Kimmeridgian rocks in Scotland are restricted to two sedimentary basins, the Hebrides Basin in the west and the Inner Moray Firth Basin in the east (Figure 5.1). Both are fault-bounded basins, formed to a large extent by normal movements on fault belts that have complex movement histories, and which are marked by the Minch and the Great Glen Faults respectively. In each basin, one Oxfordian section shows a thick sandy succession, which may be interpreted as near-shore (Elgol in the Hebrides Basin and Brora in the Inner Moray Firth Basin), while a second section in each basin (respectively Staffin and Balintore) shows a more argillaceous and probably deeper-water facies (Figure 5.2).

Due to their occurrence in fault-bounded basins, the various facies of the Oxfordian sediments in Scotland are often in marked contrast to those in England (Chapters 2–4). In the south, Oxfordian sediments were laid down in a wide epicontinental sea dominated on the shelves by shallow-water carbonate and fine-grained clastic sediments. There is little coarse-grained sediment derived from the rapid erosion of nearby substantial landmasses, the Yorkshire Passage Beds and the coarse Beckley Sand around Oxford being exceptions. In contrast, the Scottish successions, laid down in basins receiving sediments derived from the nearby Scottish landmass, are often dominated by coarse, clastic sands, with minimal carbonate sediment (Figure 5.2). Units such as the Brora Sandstone and the Scaladal Sandstone mark areas where rivers draining the Scottish landmass dumped large quantities of coarse, clastic sediment into the rapidly subsiding basins. Only Staffin in northern Skye was sufficiently distant from the landmass for argillaceous sedimentation to predominate, and even here silty and sandy intervals divide up the succession.

In the Kimmeridgian in Scotland, there is a marked contrast between west and east. In the west, on northern Skye, apart from thin, silty incursions, the facies of the Kimmeridgian is predominantly argillaceous, deposited in deep water distant from sources of clastic debris. In the Inner Moray Firth Basin, the Kimmeridgian succession, as seen near Helmsdale, is dominated by the Helmsdale Boulder Beds, which comprise thick accumulations of coarse, bouldery debris derived from the rising Scottish landmass and dumped rapidly into the subsiding basin. The boulders are contained within a silty, argillaceous matrix. This is a very localized deposit, and beds containing boulders do not extend far offshore. Uplift of the Scottish landmass, of the order of 1000 m overall, must have periodically resulted in the formation of low cliffs close to the bounding Helmsdale Fault (Figure 5.1). These cliffs were attacked by waves, producing accumulations of beach boulders on the shelf to the west of the fault. These were then transported off the shelf into the hanging-wall basin during storms. This represents one of the most spectacular episodes in British Mesozoic geology.

Considering the remoteness of many of the exposures, a remarkable amount of work was carried out on the Scottish Oxfordian during the 19th century. In the west, MacCulloch (1819) was the first to note the presence of strata of Oxfordian age on Skye. Murchison (1829a) visited these exposures, but unfortunately assigned the Great Estuarine Series (and the overlying Oxfordian shales) to the Wealden Group. Forbes (1851) corrected this mistake, recording cardioceratids from these shales, which he equated with the Oxford Clay Formation of England. The major account of the Mesozoic rocks of western Scotland by Judd (1878), though interesting from a historical aspect, is of lesser importance in connection with the present account, as the only Oxfordian outcrops Judd visited were those on the Isle of Eigg.

The significant outcrops of Oxfordian strata on southern Skye were first recorded by Wedd (1910) in Peach and Horne's classic memoir. Hudson and Morton (1969) and Turner (1966, 1970) added to this earlier account, but it was Sykes (1975) who provided the definitive description.

MacGregor (1934) produced the first modern account of the Oxfordian rocks at Staffin. Anderson and Dunham (1966) published maps of the foreshore outcrops here, with sections and logs. Turner (1966, 1970) described Lower Oxfordian ammonites from these exposures. Sykes (1975) prepared the first modern stratigraphical synthesis of the Staffin

exposures, and with J.H. Callomon (Sykes and Callomon, 1979) provided a detailed account of the sequence of ammonite zones seen there. Wright (1973, 1989) published revised maps of the Staffin exposures, with a description of the Kimmeridgian succession, and Morton and Hudson (1995) produced a definitive account of this area.

In the east, Murchison (1829b) first recognized the presence of Callovian and Oxfordian sections in the Moray Firth area. Numerous descriptions of parts of the succession were subsequently published by various authors, and Judd (1873) listed many of these in his masterly account of the Mesozoic rocks of this area. Workers in the first half of the twentieth century included Lee (1925), who provided further descriptions of the exposures, and Bailey and Weir (1932) who investigated the Kimmeridgian Boulder Beds. Arkell (1933) summarized our knowledge of the Scottish Oxfordian and Kimmeridgian as understood at that time. During the second half of the 20th century, Sykes (1975) produced a definitive account of the Oxfordian sequences at Balintore and Brora, and the Kimmeridgian succession, particularly the Boulder Beds facies, has been investigated by Pickering (1984) and Wignall and Pickering (1993).

Problems of correlation of the Scottish sequences with those of England have been largely resolved in recent years. In the Early Oxfordian, the typical cardioceratid succession of England is precisely represented in Scotland (Turner, 1966). In the Middle Oxfordian, the perisphinctids, upon which Callomon (1960) based the English subzonal succession, are less common, occurring abundantly only at certain horizons. The Scottish Middle Oxfordian is zoned by means of the Boreal cardioceratids, and as it has been possible to extend this Boreal zonation into England (Sykes and Callomon, 1979; Wright, 1997) the correlation with the perisphinctid-dominated sequences is reasonably well established.

In the lower part of the Scottish Upper Oxfordian, the perisphinctids of England, typified by those of the Dorset Clavellata Formation, are largely absent, but correlation is established by the common occurrence of the Boreal *Amoeboceras* of Scotland, and of the Sub-Boreal perisphinctids of Dorset, in the Yorkshire Oxfordian (see site reports for Newbridge and Nunnington, this volume). In the late Late Oxfordian and in the Early Kimmeridgian, there was much more mixing of faunas, and the typical English perisphinctids, such as *Ringsteadia*, *Pictonia* and *Rasenia*, are common in Scotland, while the Boreal cardioceratid *Amoeboceras*, so prolific in Scotland, made its way into southern England. It is, however, extremely scarce south of Swindon (Sykes and Callomon, 1979) so that correlation between Scotland and southern England is undertaken on the basis of perisphinctid faunas. Though prolific, those of Scotland are largely undescribed at present. During the Kimmeridgian Age, the perisphinctids proliferated throughout England and Scotland, so that the perisphinctid-based zonal sequence of the Kimmeridgian Stage established in England, and set out by Cope (1980), is readily applicable in Scotland.

Details of the main lithologies and depositional environments are included in the site descriptions that follow. In the following list of sites, arranged from east to west, (O) indicates that the site belongs to the Oxfordian GCR Block and (K) to the Kimmeridgian GCR Block. The location of sites is shown in (Figure 5.1).

[Balintore \(O\)](#)

[Bror \(O\)](#)

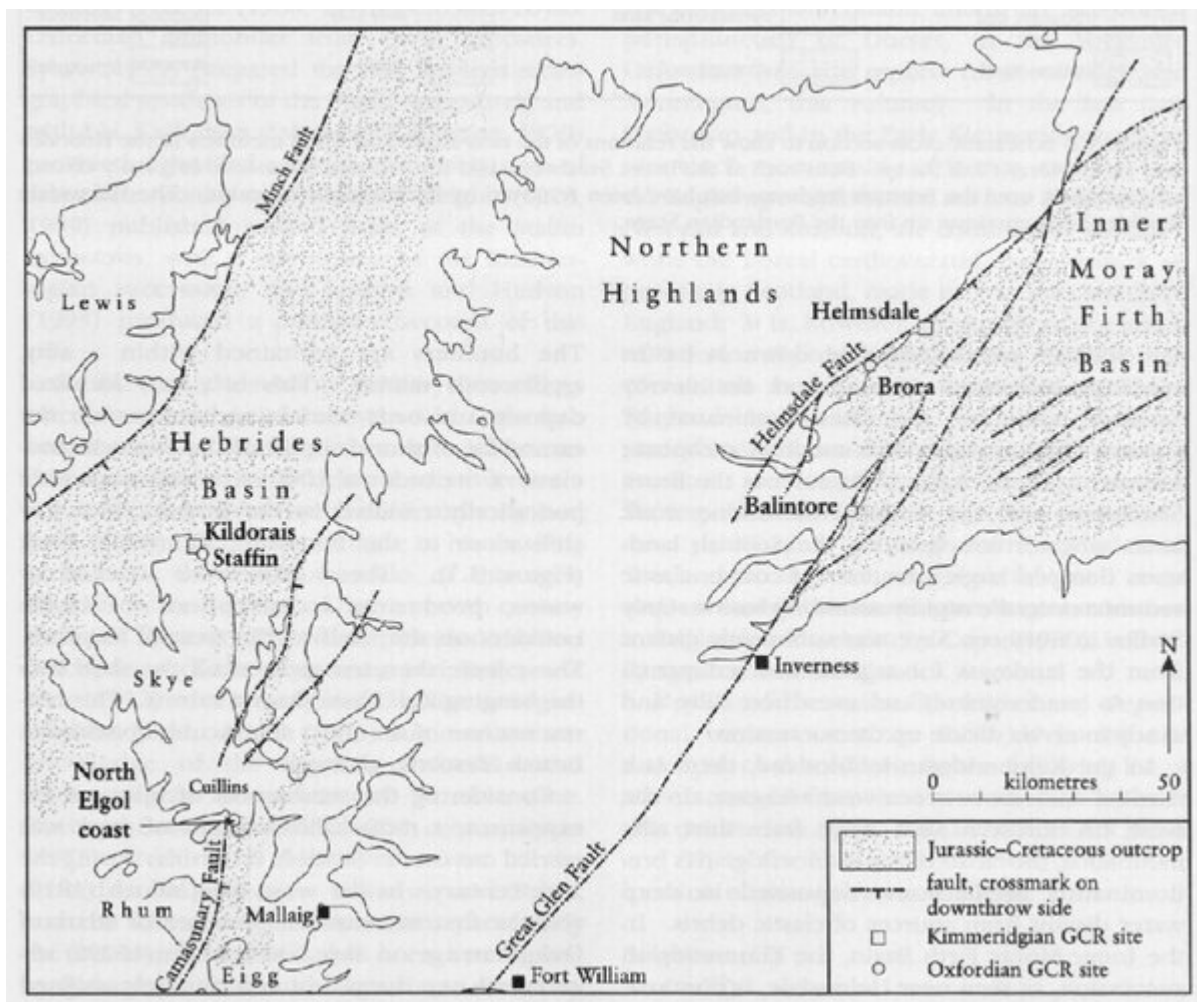
[Helmsdale \(K\)](#)

[Staffin \(O\)](#)

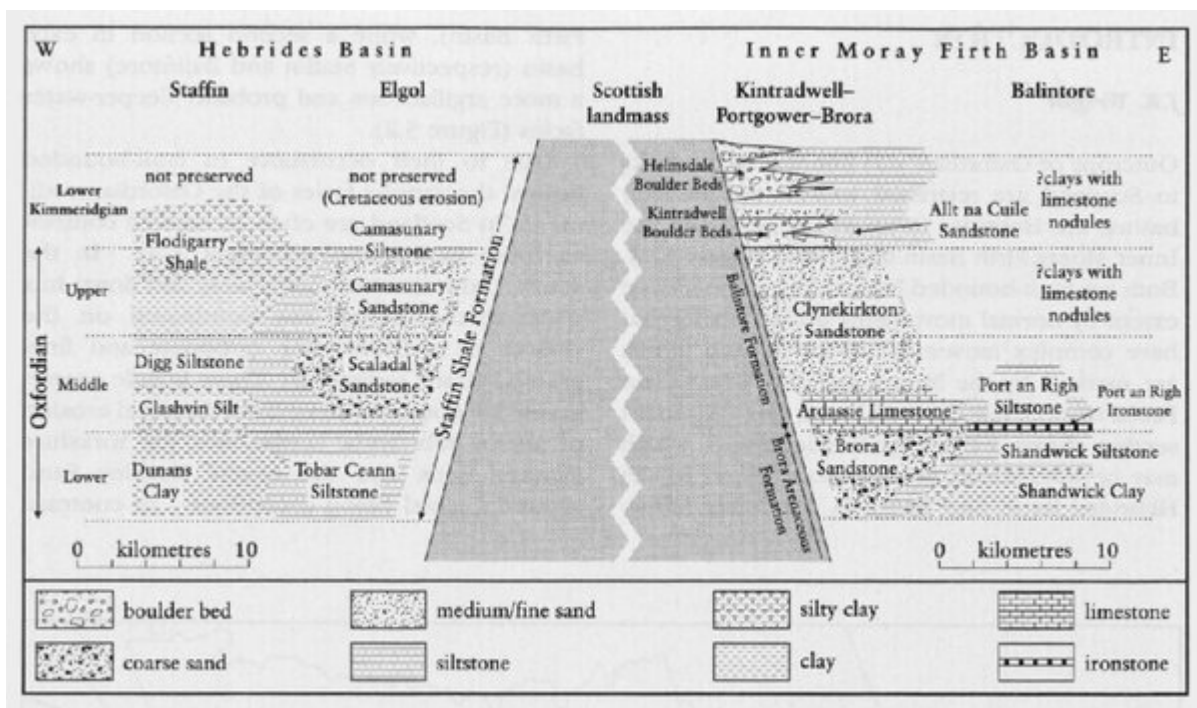
[Kildorais \(K\)](#)

[North Elgol Coast \(O\)](#)

[References](#)



(Figure 5.1) Map of northern Scotland, showing the principal Jurassic sedimentary basins and their structural controls, and the locations of Oxfordian and Kimmeridgian GCR sites. Based on BGS 1:1 500 000 Tectonic Map of Britain, Ireland and Adjacent Areas (1996) and BGS 1:1 000 000 Geological Map of the United Kingdom, Ireland and the Adjacent Continental Shelf (1991).



(Figure 5.2) Schematic cross-section to show the relations of the near-shore and distal members in the Hebrides and Inner Moray Firth Basins. Beds such as the Brora Sandstone and the Ardassie Limestone originally extended eastwards over the Scottish landmass but have been removed by Kimmeridgian erosion. The Helmsdale Boulder Beds continue up

into the Portlandian Stage.