Brora

[NC 914 040]

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Introduction

The site comprises gently dipping foreshore exposures of Middle Oxfordian strata that form Ardassie Point, east of Brora (Figure 5.6), and which constitute part of the most northerly onshore outcrop of Oxfordian strata in northwest Europe. In addition, outcrops of Lower and Middle Oxfordian sandstones and siltstones on both sides of the River Brora lie only a few hundred metres to the east of the Helmsdale Fault system, and some 500 m east of the centre of Brora itself.

In 1826, Murchison (1829b) visited and briefly described the area, although the foundations for modern geological work were laid by Judd (1873). The Middle and Upper Jurassic rocks of the Brora district were later studied by the Geological Survey (Lee, 1925), with detailed comments on the ammonite fauna by Buckman (1923–1925, pp. 48–50) and Arkell (1933). Sykes (1975) undertook a detailed description of the section during his revision of Oxfordian stratigraphy in northern Scotland.

Description

The following is taken from Sykes' (1975) description of the exposures seen in the banks of the River Brora west of the A9 road bridge and at Ardassie Point:

Balintore Formation	
Ardassie Limestone Member,	
Vertebrale Subzone	
2. Fossiliferous, muddy, carbonaceous sandstone alternating with carbonate-rich beds 0.3–1.1 m thick	seen to 12 m
Brora Arenaceous Formation	
Brora Sandstone Member,	
?Mariae and Cordatum Zones	
1. Fine-grained, friable sandstone with occasional lenticular quartz conglomerates. Large-scale cross-bedding and trough cross-bedding is present. The fauna is poor; only *Gryphaea dilatata* J. Sowerby is recorded	greater than 30 m

The major part of the Brora Sandstone is exposed in the banks of the River Brora. The member can be followed continuously from its base 540 m west of the bridge to a fault 140 m east of the bridge (Sykes, 1975). There is then an unknown stratigraphical gap before the highest beds are seen south of Ardassie Point. This locality contains the type section of the overlying Ardassie Limestone Member. The 12 m section of these beds is visible as several ledges running out to sea at low tide. The limestones are more accurately described as slightly sandy *Rhaxella* spiculites with the opaline sponge spicules replaced by calcite (Sykes, 1975). A stratigraphical log of the section is given in (Figure 5.7). Higher, Middle and Upper Oxfordian beds, com prising 400 m of sandstones, shelly siltstones and mudstones, and seen only in boreholes, were named the Clynekirkton Sandstone by the BGS (1998b). This unit is treated here as a member of the Balintore Formation.

Interpretation

The distribution of the fossil assemblages, almost exclusively ammonites and bivalves, is overridingly facies-controlled. The Brora Sandstone Member has so far yielded no ammonites, although casts of marine bivalves occur throughout. The

member would appear to include most of the Mariae and Cordatum Zones. By contrast with this sparse fauna, a rich ammonite and bivalve fauna is found in the Ardassie Limestone. The bivalves are dominated by *Cucullaea* sp. accompanied by large *Gryphaea dilatata* and *Pinna lanceolata* J. Sowerby in life position. The ammonite fauna includes *Cardioceras* (*Subvertebriceras*) *densiplicatum* Boden, *C.* (*S.*) *sowerbyi* Arkell, *C.* (*Scoticardioceras*) *excavatum* (J. Sowerby), *C.* (*Plasmatoceras*) *tenuicostatum* Nikitin (illustrated in (Figure 5.5)) and *Perisphinctes* sp., a fauna indicating the Vertebrale subzone (tenuistriatum horizon of Sykes and Callomon, 1979) (Densiplicatum Zone).

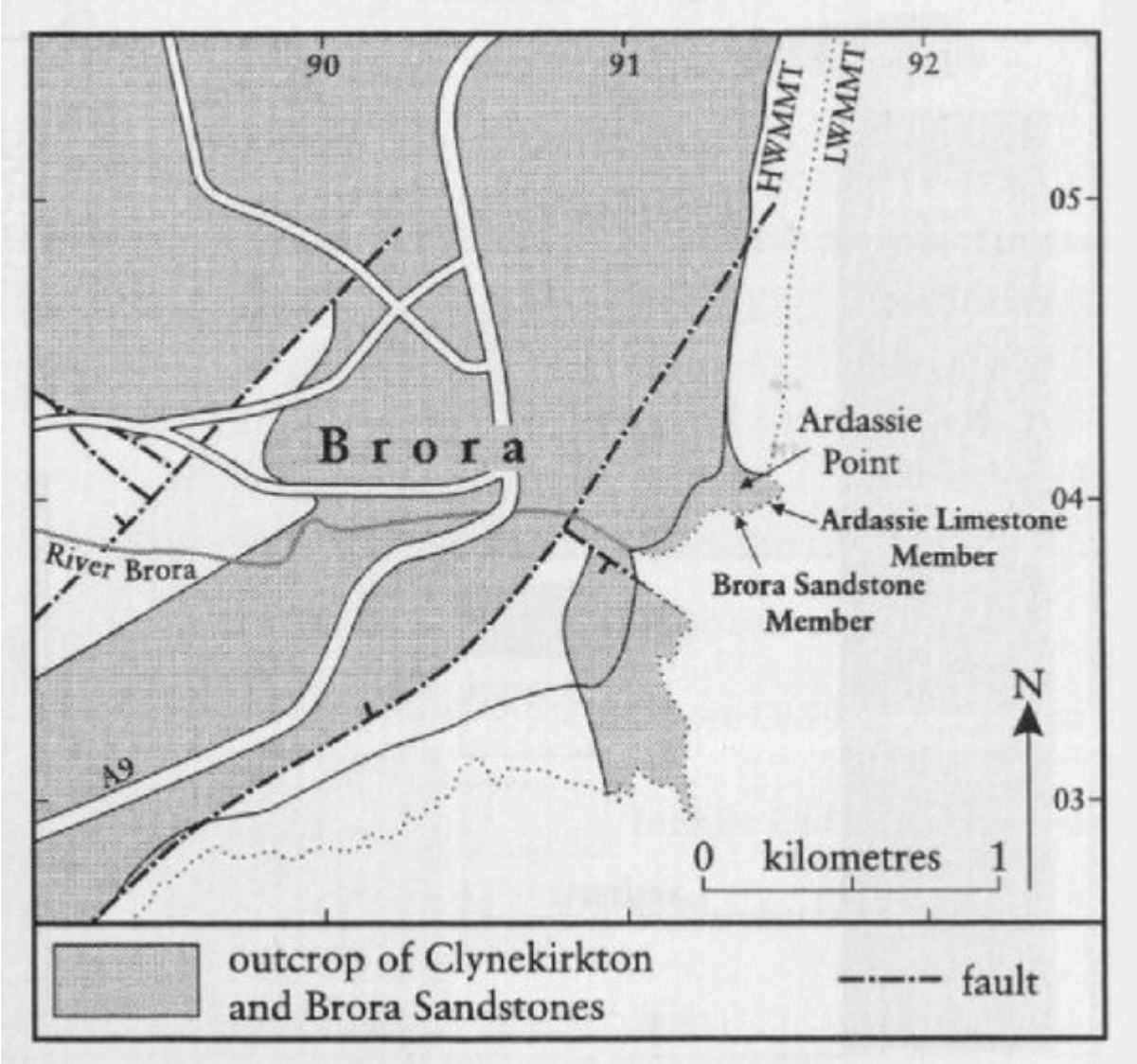
Lithologically, these deposits contrast with the clays and siltstones of similar age found at Balintore 28 km to the south. There, the Shandwick Clay and Shandwick Siltstone members represent the lateral counterparts of the Brora Sandstone at Brora, and were clearly laid down in a more offshore, deeper-water environment than that at Brora. Yet the location of the Brora and Balintore exposures is very similar, being in downfaulted blocks adjacent to major faults. The Helmsdale Fault controlled the west-em margin of the Inner Moray Firth Basin during the Oxfordian Age (Figure 5.1), with coarse clastic material being brought from the west across the fault and deposited at Brora in large foresets and troughs at the margin of the basin. This did not happen at Balintore, where the sediments adjacent to the Great Glen Fault typify those laid down in an area well removed from clastic input. Holgate (1969) proposed a solution to this dilemma involving 29 km of post-Jurassic dextral strike-slip movement on the Great Glen Fault. By this means, the Balintore Section was situated some 15 km offshore from Brora in the Oxfordian, well out into the Inner Moray Firth Basin (Figure 5.8). The post-Jurassic movements then brought the Balintore section close to the high ground of the Hill of Nigg.

The possibility of such strike-slip movement along the Great Glen Fault has been investigated by a number of authors in recent years, and the maximum amount of movement that seems possible is 8 km. The evidence is summarized by McQuillan *et al.* (1982). It is more likely, according to these authors, that during the Jurassic extension that produced the Moray Firth basins, and which was permitted by 8 km of dextral strike-slip movement along the Great Glen Fault, the western margin of the Moray Firth Basin moved westwards to the Helmsdale Fault. During the Oxfordian Age, deeper-water sediments were laid down on both sides of the Great Glen Fault in the area now occupied by Balintore, and the present pattern of a hilly area adjacent to the fine-grained Oxfordian sediments was produced by normal faulting in late Tertiary times. Such considerations apply only for the Lower Oxfordian, for coarse-grained clastic sediments are absent from both Brora and Balintore in the Middle Oxfordian, with the Ardassie Limestone being the approximate equivalent of the Port-an-Righ Ironstone.

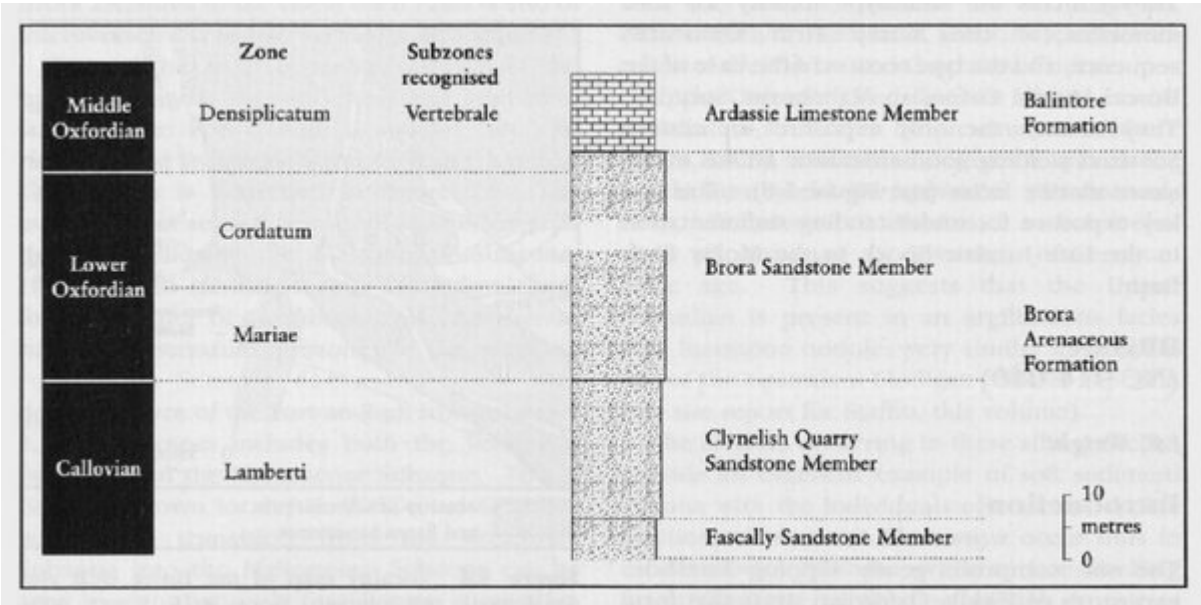
Conclusions

This is a key locality for studies of the biostratigraphy and palaeogeography of the region adjacent to the Scottish landmass and on the edge of the Inner Moray Firth Basin. The site exposes one of the type sections of the Brora Sandstone Member (Mariae and Cordatum Zones), and the type section of the Ardassie Limestone Member (Vertebrale Subzone), a carbonate facies unique to this part of Scotland. The ammonite assemblage is confined to the Ardassie Limestone and includes Boreal cardioceratids and one of the most northerly occurrences of Tethyan perisphinctids.

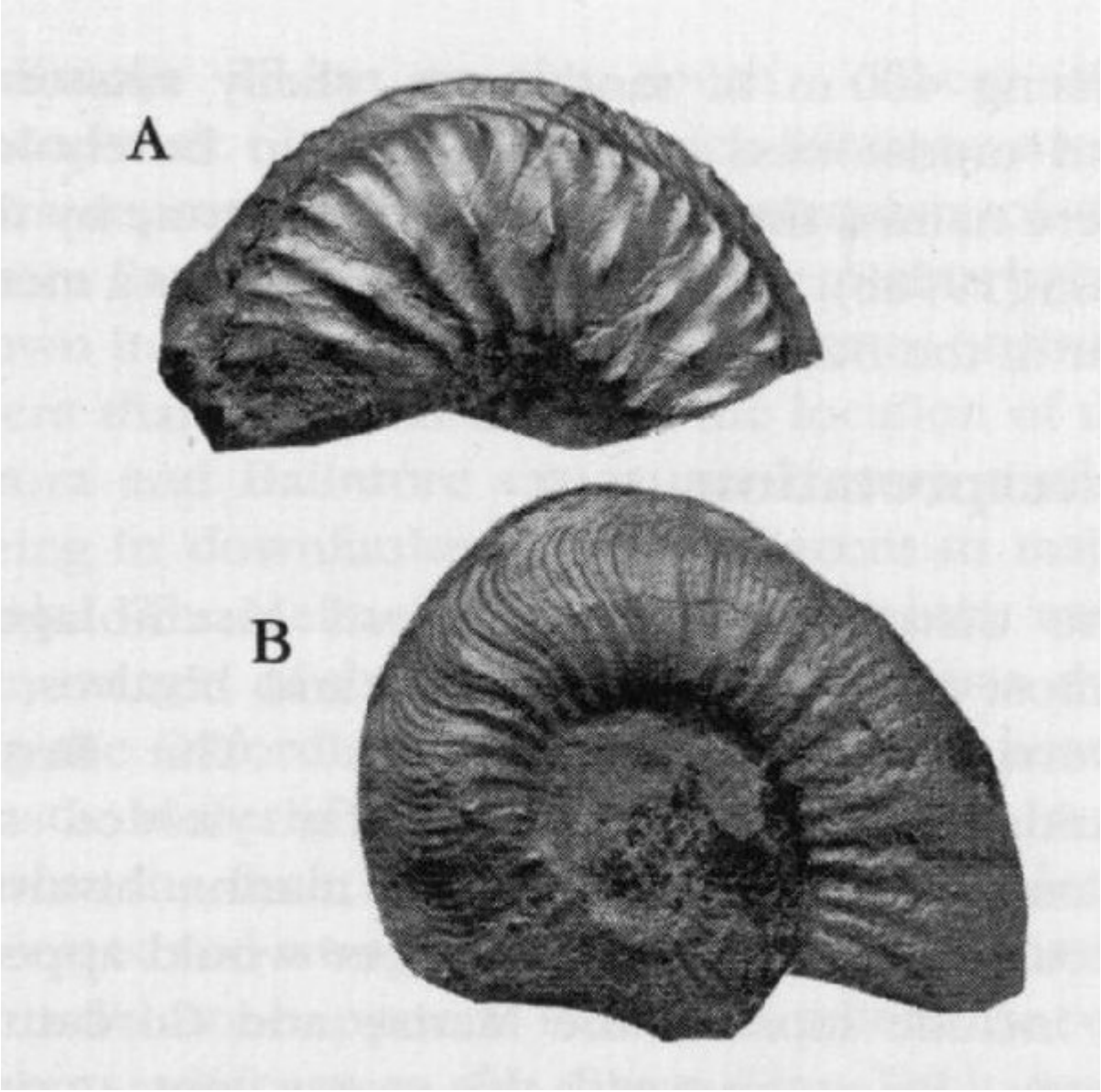
References



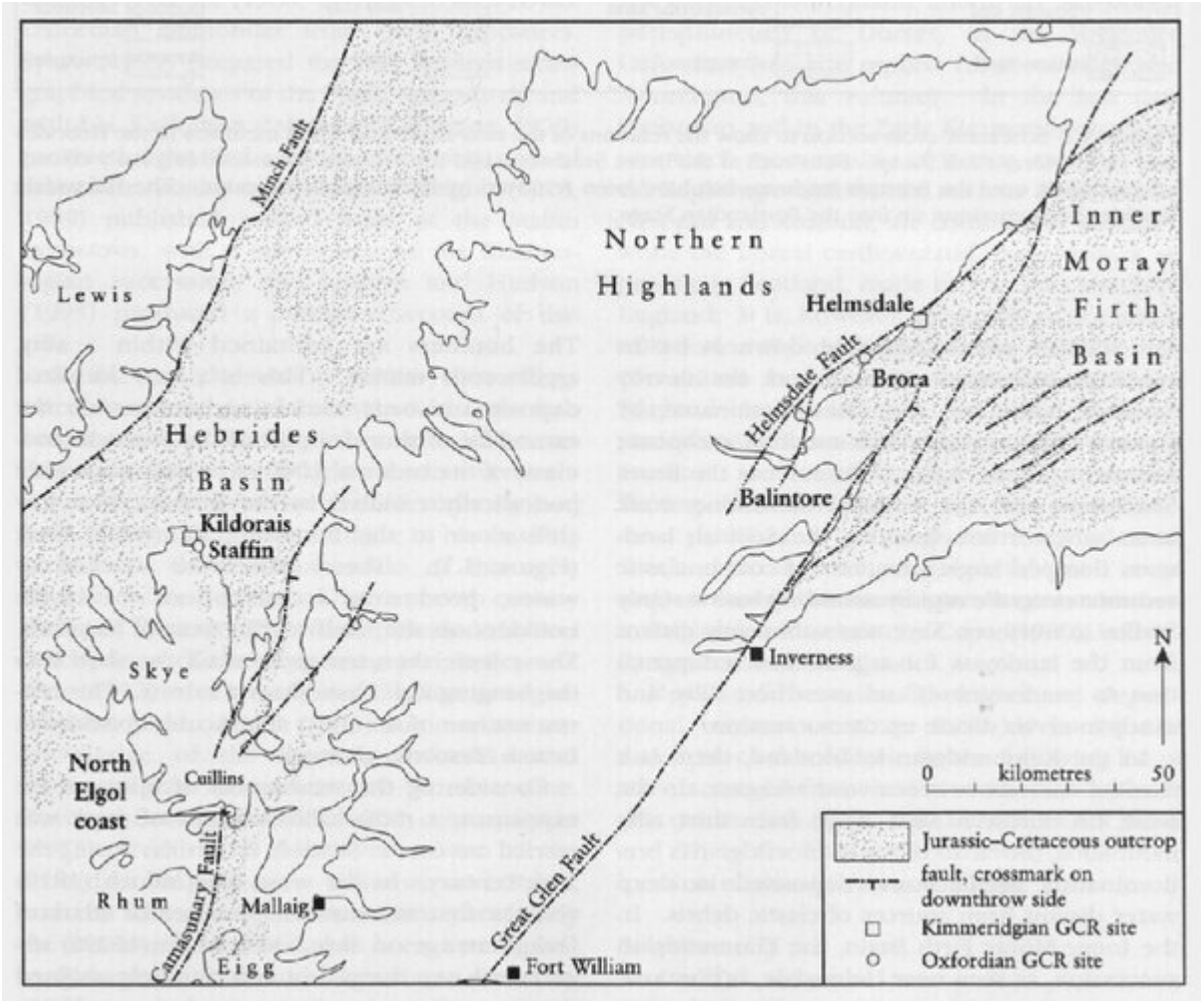
(Figure 5.6) Locality map of the Brora GCR site. Geological information from BGS Sheet 103E (Helmsdale) (1998).



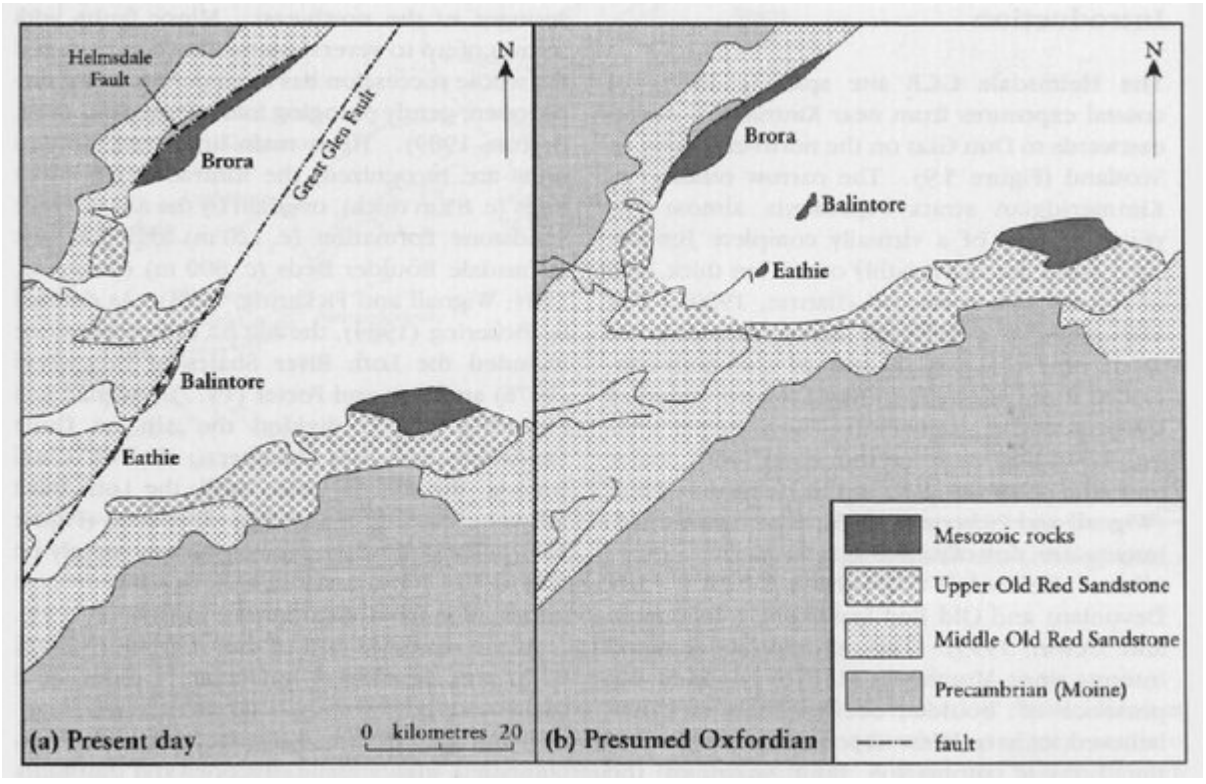
(Figure 5.7) Stratigraphical log of the Brora section (after Sykes, 1975, fig. 3).



(Figure 5.5) Ammonites from the Balintore Formation of eastern Scotland. (A) Cardioceras (Subvertebriceras) densiplicatum Boden. Bed 4, Port-an-Righ Ironstone Member, Balintore, ES3, x1. (B) C. (Plasmatoceras) tenuicostatum Nikitin. Ardassie Limestone, Brora, ES2, x 1. (Photos: K. D'Souza. Specimens in the J.K. Wright Collection.)



(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 5.8) Diagram showing possible post-Jurassic movement on the Great Glen Fault (after Sykes, 1975, fig. 2).