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## Freshwater East (South)

[SS 017 975]

### Introduction

The geology of south-west Pembrokeshire to the north and south of Milford Haven is set within five main structural areas that are separated by major E–W trending faults (Figure 4.23). Each of these areas has Silurian strata, though the succession and therefore geological history of each differs in detail (Figure 4.24). The present locality lies within the Freshwater Block, to the south of the Ritec Fault.

Murchison (1839) described the Silurian and Old Red Sandstone rocks of Freshwater East. Shortly afterwards De la Beche (1846) gave a log of these strata on the north side of Freshwater East Bay, and in the same work he set up the Coralliferous Series and Gray Sandstone Series for two of the main divisions of the Silurian of Pembrokeshire as a whole. Phillips (1848) added further comment on the Silurian strata of Freshwater East as well as other rocks of this age elsewhere in the region.

The most detailed description of Freshwater East is that by Dixon (1921) in the Pembroke and Tenby Memoir, in which he assigned the fossiliferous Silurian strata below the Old Red Sandstone to the Wenlock Series and the Ludlow Series, without recourse to using either the Coralliferous or Gray Sandstone divisions of De la Beche. Walmsley and Bassett (1976), in their investigation of the biostratigraphy and correlation of these divisions, assigned lithostratigraphical group status to both of them, and determined that the Coralliferous Group straddles the Llandovery–Wenlock boundary and that the Gray Sandstone Group is entirely of Wenlock age. The lower part of the succeeding Old Red Sandstone in Pembrokeshire (Allen and Williams, 1978; Williams *et al.*, 1982), comprising the older formations of the Milford Haven Group, is also of (probably variable) Silurian age. The Skomer Volcanic Group, the fourth major lithostratigraphical division of the system in the region, belongs to the Llandovery Series (Zeigler *et al.*, 1969).

At Freshwater East (South) the Gray Sandstone Group includes relatively numerous fossiliferous horizons (Walmsley and Bassett, 1976) that help to provide a Wenlock age for this unit which is widespread in south-west Pembrokeshire. In addition the succession at this site — the absence of any Silurian sediments beneath the Gray Sandstone Group, with the latter lying above Ordovician sediments — is representative of that within the Freshwater Block as a whole.

### Description

A broadly anticlinal structure with a WNW–ESE trending axis runs through the bay at Freshwater East (Dixon, 1921; Bassett, 1982a; Williams *et al.*, 1982). The core of the fold, here inferred to be formed of Llanvirn rocks as are present at Freshwater West along strike, is not exposed, though the northern and southern limbs of the fold are represented by outcrops of the Gray Sandstone Group and the Old Red Sandstone on both the north and south sides of the bay. The site described here takes in only those exposures of the Gray Sandstone Group on the south side of the bay, with the north side of the bay meriting GCR status in its own right as a (P<sup>■</sup>ídolí Series) site of palaeobotanical importance (Edwards, 1979; Cleal and Thomas, 1995).

Some 60 m of the Gray Sandstone Group occur in cliff and foreshore exposures, the strata dipping 40–50° to the SSW (Dixon, 1921; Walmsley and Bassett, 1976; Bassett, 1982a; Siveter *et al.*, 1989; (Figure 4.26)). The lowest 10 m are made up of grey-green sandy siltstones, mudstones and decalcified sandstones, the latter commonly known as rottenstones. These beds have yielded *Pembrostrophia freshwaterensis*, *Atrypa reticularis*, *Leptaena* sp., *Howellella* sp., *Obturementella* ? sp., *Microsphaeridiorhynchus* ? sp., *Salopina conservatrix*, *Acaste subcaudata*, favositid corals, bivalves, cephalopods and gastropods. The next 50 m comprise sandstones, sandy mudstones and occasional horizons of granulestones and shales, with rot-tenstone horizons becoming more common. In addition to the above fauna, *Marklandella giraldi*, *Lingula* sp., *Nucleolites* sp., *Holopella*, sp., tentaculitids and *Trimerus* sp. have been recorded (Bassett, 1982a). These faunal elements as a whole form part of Fauna TV of Walmsley and Bassett (1976), which

indicates an age no younger than mid- to late Wenlock. Chitinozoans recovered from horizons high in the Gray Sandstone Group may be of Wenlock age and have an upper age limit no younger than early Gorstian (Lister in Walmsley and Bassett, 1976).

Invertebrate material from the Gray Sandstone of Freshwater East (South) was figured in several early, important publications, those of Murchison (1839) and Phillips (1848) for example, and the site represents the type horizon and locality for species of various groups, for instance the brachiopod *P. freshwaterensis* (Bassett, 1971), and the bivalve *Nucula coarctata* Phillips, 1848.

The Old Red Sandstone succeeds the Gray Sandstone Group in the form of basal conglomerates, then sandstones and siltstones of the Freshwater East Formation. The contact between these two units at Freshwater East (South) is apparently marked by a minor strike fault, though at Freshwater East (North) they show an unconformable relationship (without angular discordance).

## Interpretation

Hurst *et al.* (1978) suggested that the Gray Sandstone Group of Freshwater West was of Ludlow age, on the basis that the sediments of the group were deposited as part of a transgression which they compared with the deepening event that is typical of the basal Ludlow; they argued that the palynological evidence from Freshwater East (see above) supported this claim. However this age determination for the Gray Sandstone is at variance with that of Walmsley and Bassett (1976) based on the macrofauna.

The macrofaunal assemblages obtained from 14 fossiliferous horizons within the Gray Sandstone Group of Freshwater East (South) indicate depth fluctuations between BA2 and BA3 (of Boucot, 1975) for nearly the whole group, with one horizon close to the top of the section being assigned to BA1 (Walmsley and Bassett, 1976). Thus in this region the group was deposited in alternating moderately to relatively shallow water, with particularly regressive and shallowest water conditions occurring in latest Gray Sandstone Group times. In general, in its lower part the group has been interpreted (Sanzen-Baker, 1972) as being of coastal marine origin, and having shallow marine, intertidal and deltaic facies in its upper horizons. The shallowing upwards of the Gray Sandstone anticipates the fluvial floodplain facies of the succeeding Old Red Sandstone.

The Pembrokeshire region was situated on the south-western margin of the Welsh Basin, north of the Pretannia landmass, during the Wenlock (Bassett, 1974a; Hurst *et al.*, 1978; Cope and Bassett, 1987; Holland, 1992). At this time the palaeoslope here was steeper than that in the area of the Welsh Borderland.

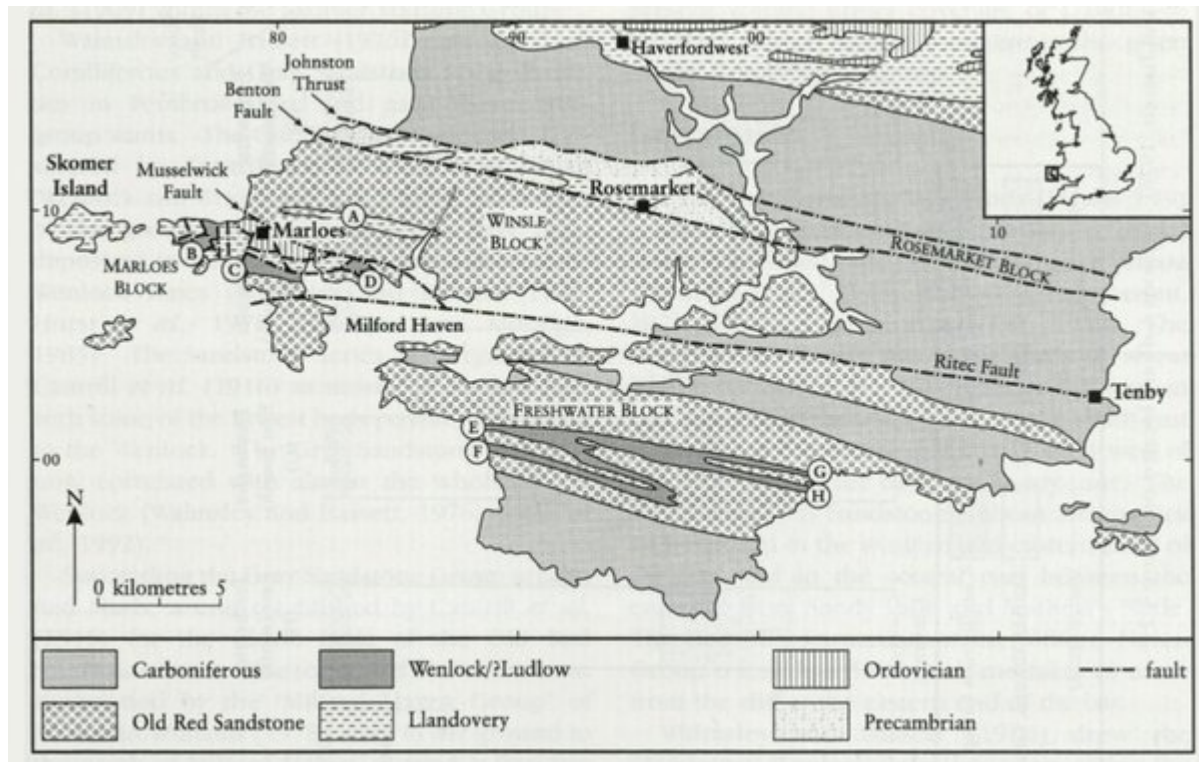
In comparison with Marloes, which is the other Pembrokeshire site described herein with Wenlock age rocks, and which is located to the north of the Ritec Fault within the Marloes Block, Freshwater East (South) lacks the Coralliferous and lower part of the Gray Sandstone groups, and the Llandovery Skomer Volcanic Group is also missing. Moreover, the base of the Old Red Sandstone at Marloes may be as old as uppermost Wenlock (Walmsley and Bassett, 1976) whereas spore evidence from the lower part of the Old Red Sandstone (Milford Haven Group; Freshwater East Formation) of the north side of the bay at Freshwater East indicates a Pridoli age (Richardson and Lister, 1969). These two sites show the type of differences that exist between the Silurian successions of separate tectonic blocks in Pembrokeshire. Such discrepancies, together with the present juxtaposition of these blocks, have been related to a telescoping effect caused by northward thrusting during the Hercynian orogeny (Sanzen-Baker, 1972).

## Conclusions

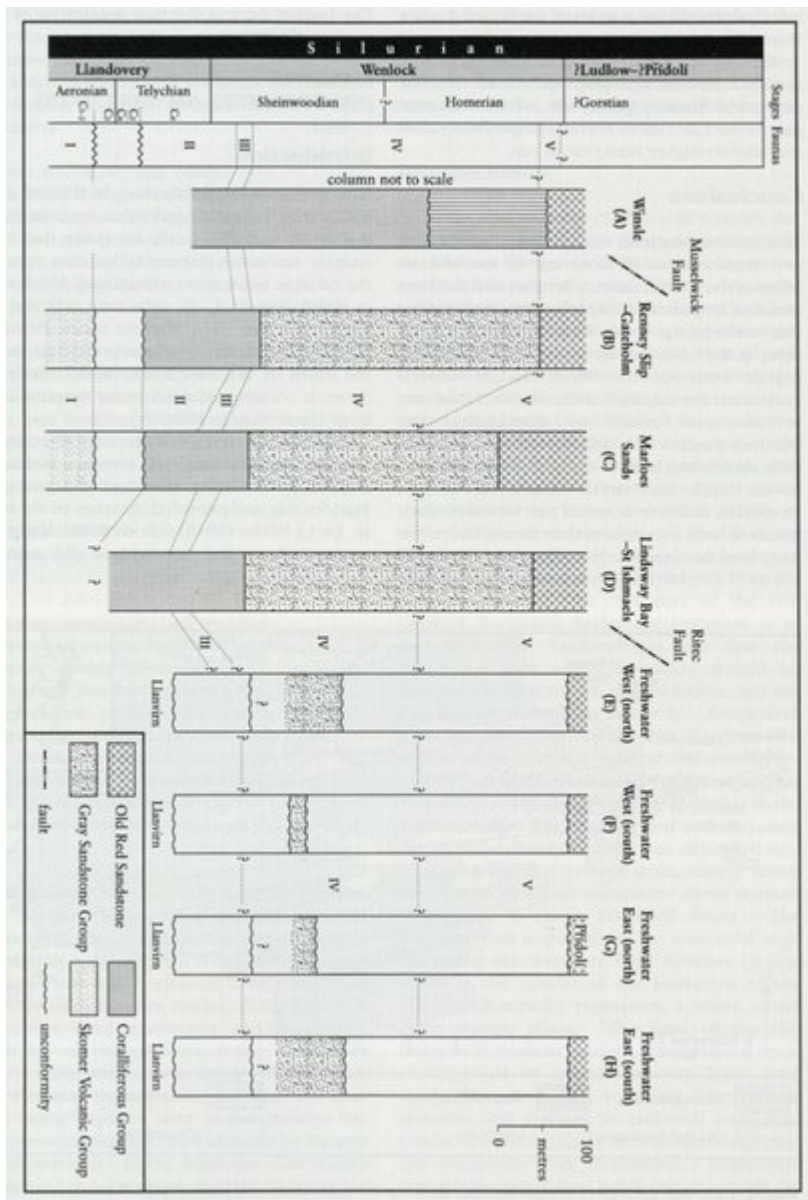
Freshwater East (South) lies structurally within the Freshwater Block and has exposures of the Gray Sandstone Group (Wenlock Series) — one of the four major lithostratigraphical units of the Pembrokeshire Silurian. Sediments of this group were deposited, generally, in relatively shallow water and the group as a whole shows a shallowing upwards sequence. In comparison with other localities in Pembrokeshire where the Gray Sandstone Group is exposed, the group here has relatively many fossiliferous horizons that have been very useful in assigning to it a Wenlock age. Freshwater East

(South) provides a contrasting Silurian section in Pembrokeshire to that of Marloes, which lies within the Marloes Block where the succession of rocks of this age is more complete. The site thus serves to demonstrate stratigraphical differences between Silurian sequences within the various structural blocks of the region. It is, also, the type locality for several species of invertebrates.

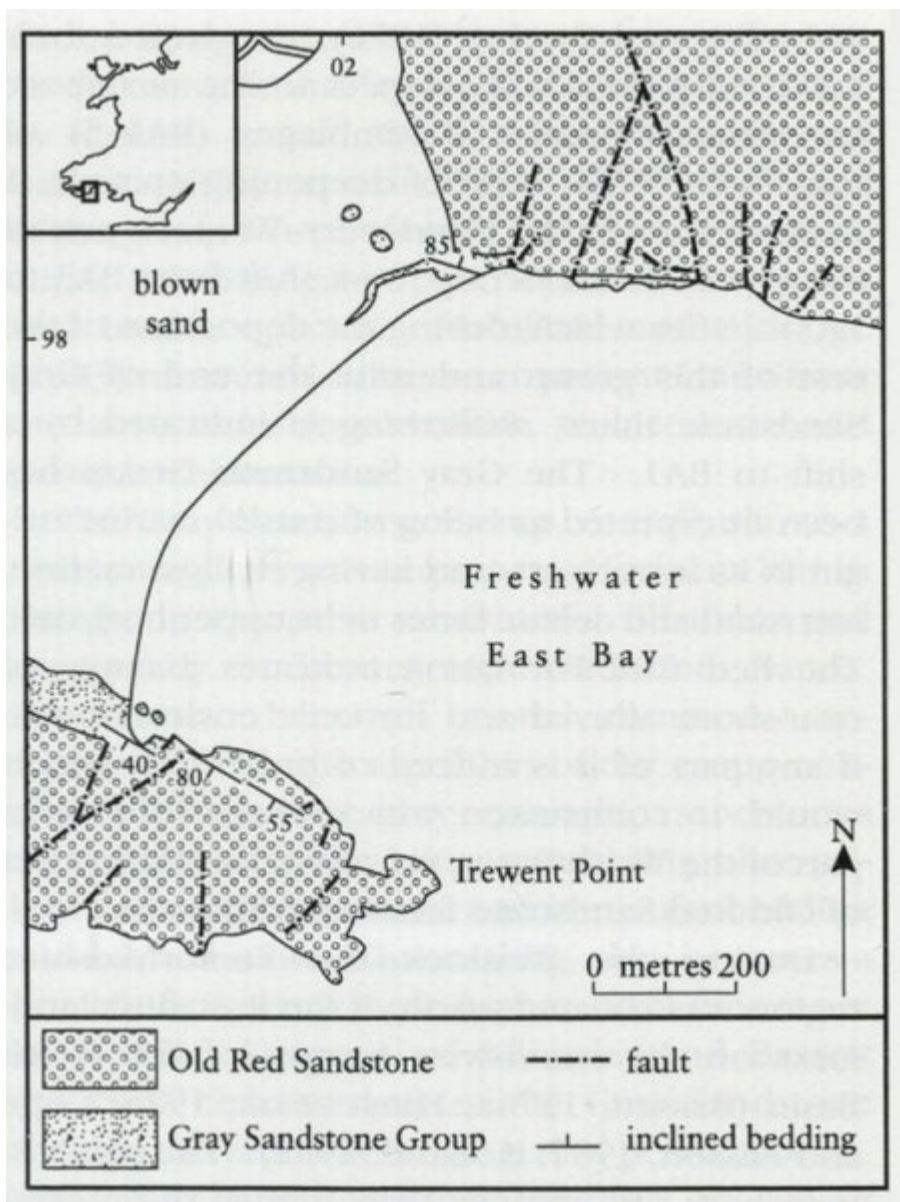
## References



(Figure 4.23) The geology of Pembrokeshire, showing the main structural blocks (after Walmsley and Bassett, 1976). The letters A-H refer to the successions in Figure 4.24.



(Figure 4.24) Correlation of Silurian sections in Pembrokeshire (after Walmsley and Bassett, 1976). Sections A-H are located on Figure 4.23.



(Figure 4.26) Geology of the Freshwater East area, Pembrokeshire (after Walmsley and Bassett, 1976).