Llansteffan, Carmarthenshire

[SN 350 100]

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>Introduction

The site is a coastal section exposing beds traditionally referred to the Red Marl Group (Lower Old Red Sandstone) of Pembrokeshire (Strahan *et al.,* 1909). The presence of the Chapel Point Calcretes Member (Psammosteus Limestone) at the site, in a magnificent development of stacked, mature, pedogenic calcrete profiles, allows subdivision of the succession, with the beds above the limestones correlated with the lowermost part of the Freshwater West Formation of south Pembrokeshire (Allen, 1978c; Allen *et al.,* 1981b; Williams *et al.,* 1982). These beds include large, fluvial, sandbodies deposited in large rivers, as well as the deposits of small, muddy, interfluvial distributaries with little sand, but much intraclast gravel. This site has provided important evidence towards the understanding of Early Devonian alluvial-plain geomorphology and drainage patterns. Apart from the type locality of the Chapel Point Calcretes Member on Caldey Island, the limestones here are some of the best examples of mature Old Red Sandstone calcrete profiles seen in the Anglo-Welsh Basin, all completely exposed in extensive cliffs. The site has been instrumental in the understanding, interpretation and significance of these calcretes.

Description

The GCR site lies immediately south of the village of Llansteffan and extends along the coast of the Towy estuary from 100 m north-east of Llansteffan Castle [SN 3526 1026] south-westwards to near St Anthony's Cottage [SN 3470 0085] in Scott's Bay (Figure 5.70). Murchison (1839) noted that the section exposed 'the finest example of a limestone of the Old Red Sandstone System in Carmarthenshire'. Strahan (in Strahan *et al.,* 1909) was the first to describe the section. More recently, Allen (1978c, 1986), Allen *et al.* (1981b), Cope (1982), Marriott and Wright (1996), Wright and Marriott (1996) and Jenkins (1998) examined the section, providing details and sedimentological analyses. Morrissey and Braddy (2004) describe animal burrows and trails in the Freshwater West Formation.

The site lies on the northern limb of the Wharley Point (or St Anthony's) Anticline, a NE-trending anticline, which lies in the hanging-wall of the Llandyfaelog Disturbance (Strahan in Strahan *et al.,* 1909). This major structure has a similar trend to the anticline and crops out close to the northern end of the site. The axis of the anticline crosses the coast south-west of the western end of the site, 230 m south of St Anthony's Cottage, the Llansteffan succession being repeated and higher strata exposed towards Wharley Point.

The Chapel Point Calcretes Member is the lowest bed exposed in the site, cropping out along the axis of the anticline (Figure 5.71) and being continuously exposed from east of Llansteffan Castle [SN 353 101] to south-west of the castle [SN 350 099]. Correlated with the regionally developed Psammosteus Limestone, it forms the uppermost part of the Moor Cliffs Formation of the Pembroke peninsula. (Figure 5.72) is a graphic log of the near-strike succession exposed in the section, on the northern limb of the Wharley Point Anticline. The following description is based largely on that given by Strahan (in Strahan *et al.,* 1909), Allen (1978c) and Allen *et al.* (1981b). The succession comprises three parts, in ascending order: thick calcretes (the Chapel Point Calcretes Member); interbedded calcretes, mudstones and intraformational conglomerates; and sandstones and mudstones in upward-fining sequences. The cliffs from below the castle for 350 m south-westwards expose 15 m comprising six closely spaced calcrete profiles. Strahan (in Strahan *et al.,* 1909) referred to the beds as massive limestone composed of concretions perpendicular to bedding. The calcretes are grey to green and rubbly to massive, and show an upward increase of maturity, with increasing carbonate content and a gradation from discrete nodules, which increase upwards in size and coalesce into rubbly and massive limestones. Irregular, horizontally laminated limestones are present locally, but the profiles have a mainly prismatic, bedding-perpendicular fabric (Allen, 1974d, 1978c, 1986; Allen *et al.,* 1981b). Allen (1974d, 1986) differentiated the calcretes on the basis of their maturity into three types. Type A profiles comprise scattered nodules (glaebules) with

locally more intense concentrations (Stage I of Machette, 1985); in Type B, the glaebules are larger and closely packed at intermediate to upper levels, giving a crude prismatic fabric (Stage II of Machette). Type C profiles represent the most mature profiles in which closely packed glaebules coalesce (Stage III of Machette) and contain laminated carbonate layers (Stage IV of Machette). Most of the calcretes in this section are of Type B (stages II to III).

Overlying the calcretes is a mudstone-dominated succession, which marks the base of the Freshwater West Formation. It contains some calcretes and three types of sandstone bodies (Allen, 1980):

- thin, mainly very fine-grained sandstones with lateral accretion structures;
- thick, mainly fine-grained, cross-bedded or parallel-laminated sandstones; and
- lenticular intraformational conglomerates.

The conglomerates are bounded above and below by mudstones, locally cross-bedded and preserve dune or bar forms and internal channelling (Allen, 1978c; Allen and Williams, 1979b). The conglomerates occur at the base of the succession and overlie erosion surfaces (Allen, 1978c; Allen *et al.,* 1981b). The calcretes, which lie within the mudstones exposed in and to the south-west of a slight embayment south-west of the Chapel Point Calcretes Member cliff, show varying degrees of maturity (but are mostly Type A) and well-developed pseudo-anticlines (Allen, 1973b).

Marriott and Wright (1996) described a section of 6 m of strata lying 10 m above the base of the Freshwater West Formation. They interpreted some of the red mudstones in the succession as originating as sand-sized mud aggregates or pellets produced in soils and deposited from bedload in small, sinuous channels, similar to the aggregates described by Ekes (1993) in the Ridgeway Conglomerate Formation of West Angle Bay.

There are several metre-scale, mainly cross-laminated, very fine-grained sandstones with lateral accretion surfaces. Between 29 m and 35 m above the base of the section is a complex of upward-fining and upward-thinning intraformational conglomerates interbedded with mudstones. The conglomerate bodies have sharp bases resting on downcutting erosion surfaces and are either cross-bedded or horizontally bedded. The higher conglomerates are thin, of granule grade and lack quartz sand (Type B of Allen and Williams, 1979b). A conglomerate near the top of this part of the section contains plant fragments and *Pachytheca.*

The upper (third) part of the succession is exposed in the cliff that extends towards St Anthony's Cottage [SN 346 099]–[SN 347 099]. Two thick, green sandstone bodies lie 80 m and 95 m above the base of the section. They are coarser and thicker than the underlying laterally accreted sandstones and contain no lateral accretion structures. The lower one is 5.2 m thick, has a thin, fish-bearing intraformational conglomerate resting on a scoured surface, and comprises parallel-laminated sandstones overlain by cross-bedded, fine-grained sandstones. At the top, 0.8 m of cross-laminated, very fine-grained sandstone passes up into calcretized mudstone. Internal erosion surfaces at the bases of sets are strewn with intraformational clasts. The higher sandstone is 7.2 m thick and comprises a complex of trough cross-bedded, parallel-laminated and cross-laminated sandstones resting on a thick basal intraformational conglomerate containing ostracoderm fragments. The burrow trace fossil *Beaconites* is very common towards the top. Allen *et al.* (1981b) referred it to *Beaconites antarcticus,* Morrissey and Braddy (2004) to *Beaconites barretti.* Arthropod trackways and foraging traces occur in mudstones near Wharley Point (Morrissey and Braddy, 2004).

Interpretation

The succession of six stacked calcrete profiles comprising the Chapel Point Calcretes Member at the base of the section correlates with the regionally developed Psammosteus Limestone. It represents a prolonged period of geomor-phological stability, with little subsidence of the alluvial floodplain or fluvial incision, allowing subaerial exposure and pedogenic carbonate formation, each profile representing periods that may have ranged between tens of thousands to millions of years (Allen, 1974d, 1986; Allen and Williams, 1979b; Marriott and Wright, 1993, 2004). Some of the mudstones/siltstones have been interpreted as originating as sand-sized pedogenic mud aggregates (pellets) produced in floodplain soils and deposited from bedload in small, sinuous channels (Marriott and Wright, 1996, 2004).

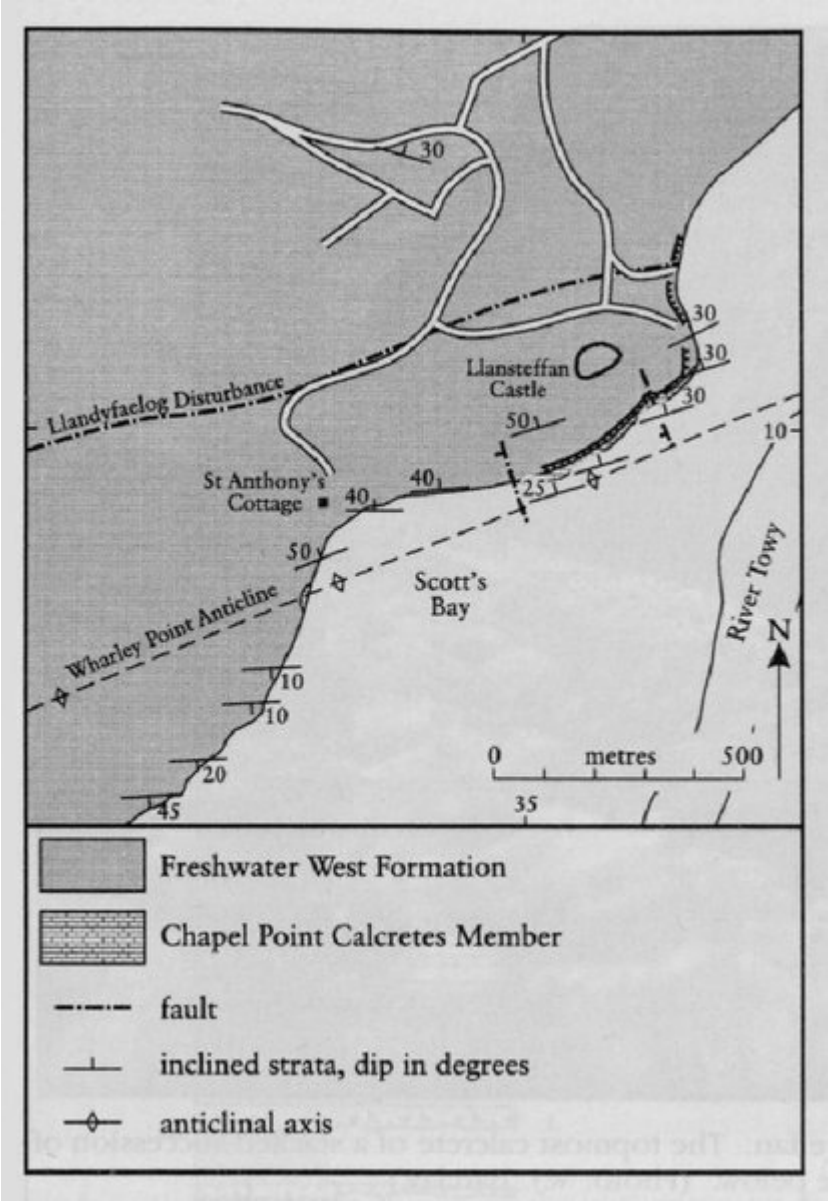
The cross-bedded, intraformational conglomerates in the overlying beds suggest deposition in broad, shallow channels. Their distribution, many as bar and dune forms within mudstones, may represent ephemeral drainage systems in interfluvial areas between the main distributary channels (Allen and Williams, 1979b; Allen *et al.,* 1981b). The cross-laminated, very fine-grained sandstones with lateral accretion surfaces may represent high-sinuosity channels with sluggish water flows. The higher conglomerates are thin sheets, also lacking in quartz sand, and suggesting deposition of reworked muds (including pedogenic mud aggregates) and calcretes in ephemeral streams and sheet floods (Marriott and Wright, 1996). The green, coarser-grained, thicker sandstones 80 m and 95 m above the base of the section are interpreted as the deposits of larger, higher-energy, low-sinuosity streams, suggesting the establishment of major rivers in the area (Allen, 1978c; Allen *et al.* 1981b). The inception of major fluvial sedimentation above the Chapel Point Calcretes Member was a regional event recognized throughout the Anglo-Welsh Basin, marking the establishment of generally south-flowing rivers from a source nearer than that of the streams which deposited the strata below the limestone (Allen and Crowley, 1983).

Conclusions

The site is of regional and national importance in providing the best onshore and most easily accessible exposure of a condensed succession of stacked Old Red Sandstone mature fossil soil carbonate (calcrete) profiles, representing the best development of the Chapel Point Calcretes Member (Psammosteus Limestone) in the Anglo-Welsh Basin. It provides important information on the contemporaneous climate, which, by analogy with the occurrence of modern calcretes, was semi-arid, seasonally wet and tropical.

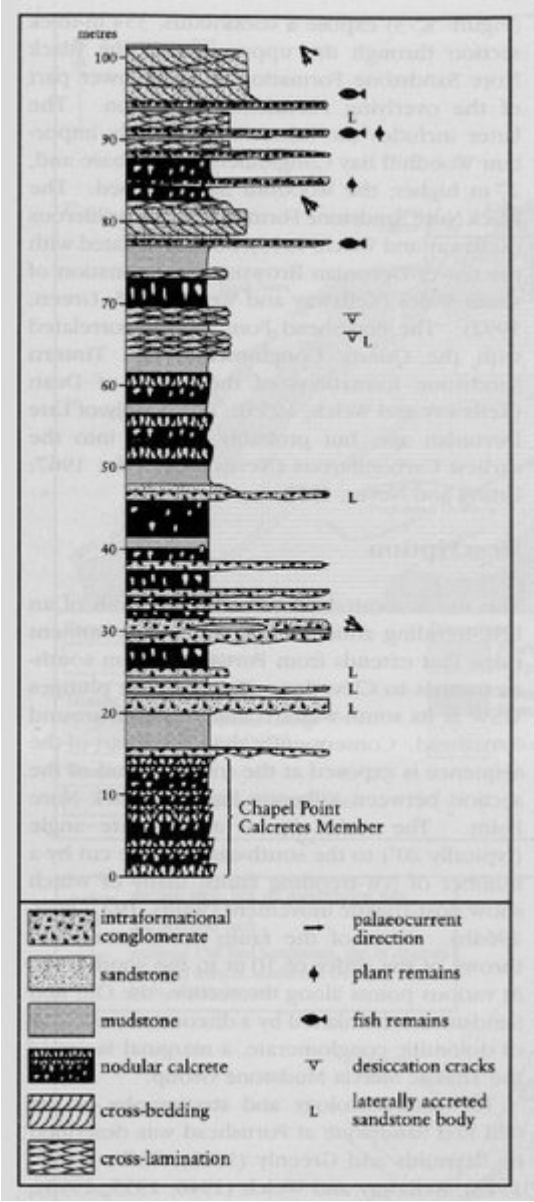
Detailed sedimentological analyses at the site have been instrumental in building models of Old Red Sandstone alluvial sedimentation. Analyses of the sandstone and intraformational conglomerate bodies have provided an insight into a range of fluvial environments, including major, sand-filled distributary channels in the higher parts of the section, and more localized shallow, ephemeral flashy streams in the lower parts. A further point of interest lies in some of the mudstones above the Chapel Point Calcretes Member, which may have originated as pedo-genic mud aggregates deposited from stream bedload or sheet floods.

References



(Figure 5.70) Geological sketch map of the Llansteffan area. After British Geological Survey 1:10 560 manuscript map Carmarthenshire 45SE (1906).

(Figure 5.71) The Chapel Point Calcretes Member, Llansteffan. The topmost calcrete of a stacked succession of calcretes overlies the careously weathered top of the one below. (Photo: W.J. Barclay.)



(Figure 5.72) Vertical section of the strata exposed at Llansteffan. Based on Allen (1978c) and Allen et al. (1981b).