Ilston Quarry, Gower, West Glamorgan

[SS 555 906]

Introduction

The Ilston Quarry GCR site is a disused quarry [SS 555 906] immediately adjacent to the hamlet of Iliston. It is the most accessible section on Gower for illustrating the cyclic nature of the Asbian and Brigantian limestones. This cydicity reflects frequent sea-level oscillations caused by the build-up and melting of Ice sheets over the southern continental mass, called Gondwana. There are at least eight cyclothemic rock units in the quarry, each separated by a clay horizon interpreted as a fossil soil, overlying an irregular dissolution (palaeokarstic) surface. This style of sedimentation, with cyclothems capped by sub-aerial exposure surfaces, is the pattern found in all post-Holkerian to late Permian limestones globally. It stands in marked contrast to that represented by older Carboniferous successions in the region that were not affected by frequent sea-level oscillations. The Ilston fossil soil horizons differ somewhat from those found in Derbyshire and North Wales (see chapters 7 and 8) in lacking evidence of arid climate intervals.

The currently accessible section falls entirely within the Oxwich Head Limestone. Above this, approximately 10 m of the Oystermouth Beds (= Black Lias of the D_3 Zone) was formerly exposed. This stratigraphical terminology follows the subdivisions recognized by the [British] Geological Survey (Institute of Geological Sciences, 1973) and George *et al.* (1976). Ramsay (1991) provided a detailed log of the section. He also defined the position of the Asbian–Brigantian stage boundary within the Oxwich Head Limestone (following George *et al.,* 1976) immediately above a couplet of clay bands and below a massively bedded unit at the northern end of the site. A general reference to the succession is made by Dixon and Vaughan (1911).

Description

The main face of this disused quarry exposes some 100 m of limestones dipping 50° NNE, although Ramsay (1991) recorded a section totalling 160 m in thickness. The bulk of the section consists of crudely cyclic, thickly bedded to massive bioclastic, peloidal and oolitic limestones, many of which show pseudobrecciated features typical of limestones of this age. Ramsay (1991) has discussed the lithofacies types for this stratigraphical interval in South Wales but the account presented here includes information from unpublished data by N.A.H. Pickard (Figure 9.28). Bioclastic ooid grainstones are the main lithology present, commonly medium- to coarse-sand grade, and these tend to be the lithology beneath the exposure surfaces. The major bioclasts are corals, crinoids, brachiopods, foraminifera and algae (e.g. *Koninckopora*); day intraclasts also occur. Bioclastic peloidal grainstones and packstones are also common, typically more bioclast-rich and with grainstone textures in the lower parts of cyclothems, and more matrix-rich in the mid parts. Less common are fine skeletal wackestones–packstones and carbonate mudstones, the latter with ostracodes. These two lithologies are confined to thin cyclothems or to the boundaries between cyclothems. Many of the limestones display irregular centimetre-sized pale-grey mottling patterns referred to as 'pseudobreccias', which is an early diagenetic product common to limestones of this age.

The most distinctive feature of the section is the presence of six distinctly recessed clay horizons, each of which is up to 0.75 m in thickness (Figure 9.28) and which contain minor thin rubble horizons. These have a high illite–smectite content. They range from green to grey in colour when fresh, and weather to red and brown, largely as a result of pyrite oxidation. Associated with this decomposition of pyrite is the production of sulphur and gypsum. The pyrite occurs as crusts on the underlying limestone, as nodules within the clays, and associated with thin organic-rich horizons at the tops of the clays. Thin coals, some with rootlets, are also present, capping many of the clays in the quarry. The underlying tops of the limestones are irregular and locally display smooth circular pits up to a metre deep and filled with clay (Figure 9.29). Unlike many other Asbian sections showing these features, calcrete crusts are not well developed.

Interpretation

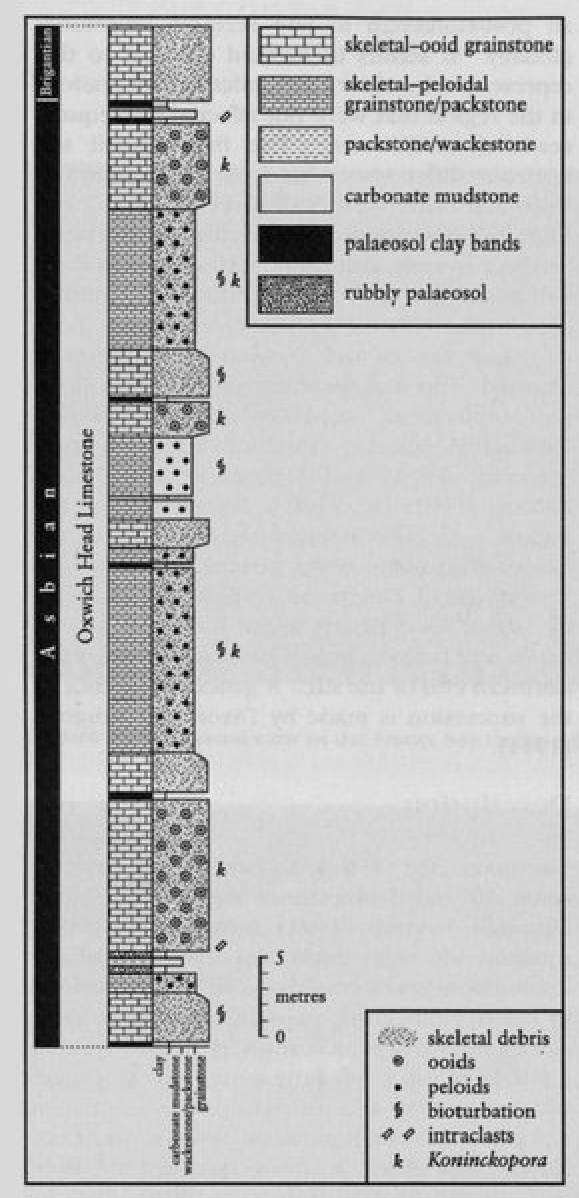
The association of limestones and clay beds with subaerial exposure features is characteristic of late Viséan sequences in Britain and elsewhere, with some 40 different stratigraphical levels showing these effects in the Asbian Stage and nine in the Brigantian Stage (Vanstone, 1996). The limestones are all of shallow-water character, with skeletal-rich grainstones representing initial transgressive phases. The more matrix-and peloidal-rich lithologies probably represent somewhat deeper and lower-energy deposits marking the deeper-water phases. The oolitic grainstones represent shallowing, highstand units. The clays are typical of Asbian and Brigantian deposits throughout Britain and have been termed 'K-bentonites', produced by the degradation of basaltic volcanic ashes. The general characteristics of these late Viséan exposure features have been reviewed by Vanstone (1996, 1998). The underlying limestone surfaces represent palaeokarsts on which small pits developed, probably initially around individual trees (Vanstone, 1998), and because of the increased drainage around these trees caused by the funneling of rainwater along branches and down the tree trunks (stem-flow effect). These surfaces elsewhere in Britian are veneered with calcrete crusts and rhizocretions, representing semi-arid intervals, as well as palaeokarstic surfaces representing more humid phases. Thus at each exposure surface a history of humid to semi-arid conditions can be identified (Vanstone, 1996). The absence of calcrete crusts and rhizocretions from the Gower surfaces has been interpreted by Vanstone (1996) as possibly reflecting deposition of these limestones in deeper water than comparable sections elsewhere in Britain. As a result, the Gower area did not become exposed until the climate had become more humid (since calcrete crusts developed under more arid conditions), the area being re-flooded before the later phase of calcrete formation could take place (Figure 9.30). The clays underwent soil development in a climate humid enough to allow the movement of iron, resulting in concentrations of iron which later became pyritized. The occurrence of this pyrite has been interpreted as due to marine hydromorphism causing sulphate reduction as the carbonate platforms were flooded by sea water. As the sea level rose, the local freshwater lenses will also have risen, which probably created freshwater ponds in which the peats formed that were later transformed into thin coals (Wright *et al.,* 1997). Vanstone (1996) has suggested that the paucity of clay soils from the bulk of the Brigantian section in the Gower was due to deepening conditions.

These late Viséan cyclothems have been widely regarded as the products of glacio-eustatic sea-level oscillations (Wright and Vanstone, 2001), taking place on a 100 000 to 125 000 year frequency (Horbury, 1989). These were most likely triggered by Milankovitch eccentricity cycles, causing cooling in higher latitudes that resulted in the build-up and subsequent melt-out of continental ice-sheets over southern Gondwana. Thus, if no cycles are missing, the main part of the section at Ilston represents about 800 000 to 1 million years. Sea-level oscillations were probably in the range of 10–30 m (Horbury, 1989).

Conclusions

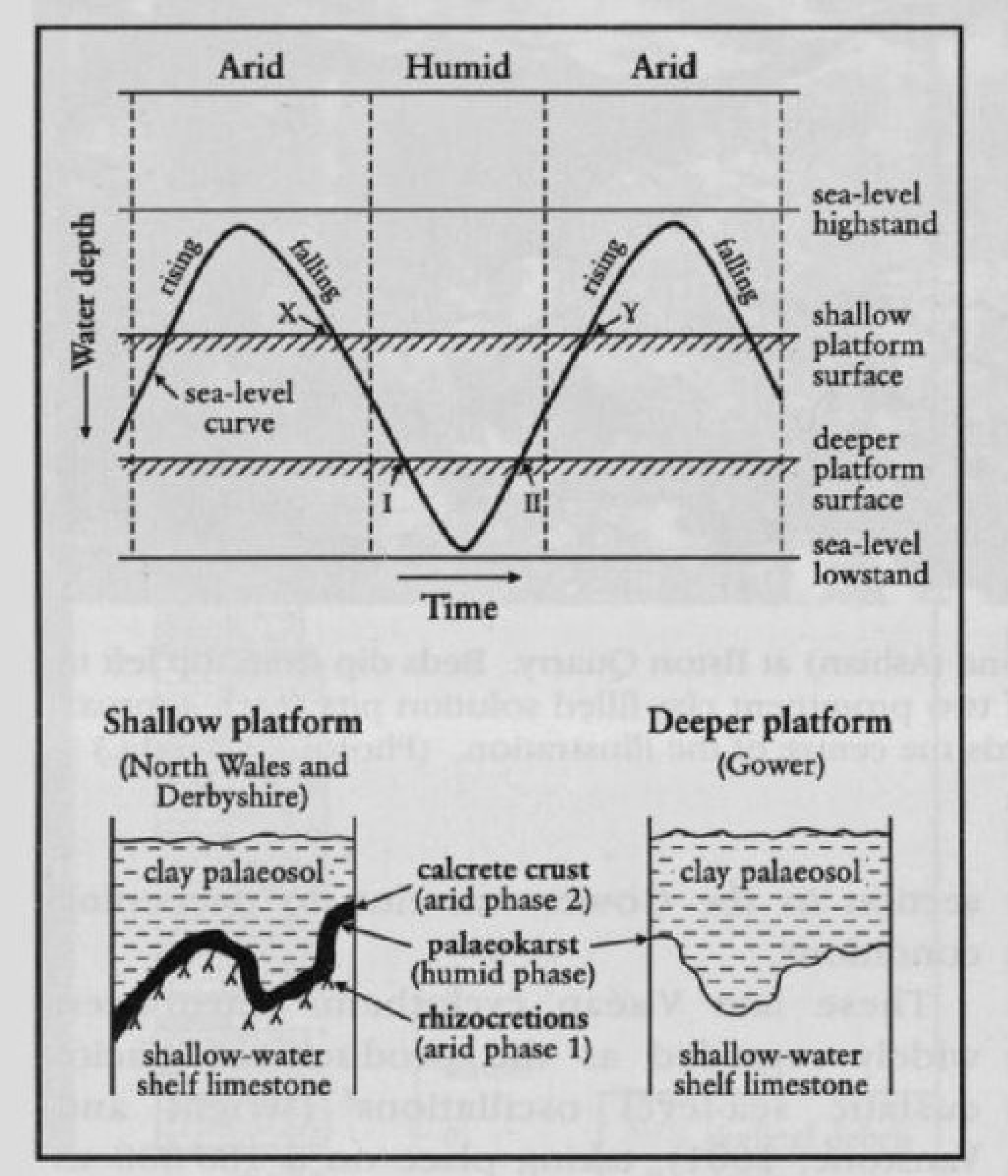
The Ilston section provides an exceptional Asbian–Brigantian section of the Oxwich Head Limestone, revealing evidence of the oscillations in global sea-level that characterized the late Viséan to late Permian world. The result of these sea-level oscillations was to create cyclic limestones with prominent subaerial exposure surfaces marked by palaeokarsts and palaeosols. These oscillations were the result of the growth and melting of continental ice sheets over the southern continental mass of Gondwana. Slightly deeper water conditions in the Gower compared to areas such as North Wales and Derbyshire resulted in the platforms only being exposed for shorter intervals, with the result that the limestones were exposed only during humid climate phases.

References



(Figure 9.28) Sedimentary log of the main quarry face in the Oxwich Head Limestone (Asbian) at Ilston Quarry showing the location of six clay palaeosols and two rubble horizons. After information supplied courtesy of N.A.H. Pickard.

(Figure 9.29) General view of the Oxwich Head Limestone (Asbian) at Ilston Quarry. Beds dip from top left to bottom right (to the north-east). Note the presence of two prominent clay-filled solution pits (each approximately 2 m deep) on a palaeokarstic surface seen towards the centre of the illustration. (Photo: V.P. Wright.)



(Figure 9.30) Model to show why the exposure surfaces at Ilston Quarry differ from those in other parts of the UK. Differences arise because of the contrasting depths of the platforms. Shallow platforms were exposed early during periods of sea-level fall, when the prevailing climate was more arid (X). As a result, the exposed carbonate sediments acted as substrates for roots that became lightly calcified in the semi-arid conditions forming rhizocretions. These shallow platforms were not flooded until late on in the rise part of each sea-level cycle, when the climate was again more arid (Y) after a humid phase. In the case of platforms that were slightly deeper (perhaps by only a few metres, as the sea-level oscillations were only in the order of 10–30 m), subaerial exposure did not take place until the climate had become more humid (I), and the exposure surface was flooded while the prevailing climate was still humid (II). The sea-level oscillation curve is here drawn as symmetric in form, but an asymmetric form is more likely, with the rise part of each cycle being rapid. After Vanstone (1996).