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Mesozoic, Syn-Rift, Non-Marine, Microbialites from the Wessex Basin, UK

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The outcrops of Late Jurassic microbialites on the Dorset coast (southern England, Fig. 1) have been known to geologists for over 175 years. They form buildups, commonly around the stumps of ancestral conifer trees, and associated with both replaced evaporites and freshwater limestones. Despite the fact that they are visited by numerous university and industrial groups each year the environment of formation of the microbialites from the Purbeck Limestone is still not clear and previous authors have described them as being deposited in either freshwater, hypersaline, lagoonal or lacustrine environments. The limestones have been considered to have been diagenetically altered by either hypersaline or freshwater fluids. The only consensus is that these are non-marine microbial limestones but they have been variously referred to as tufas, algal limestones, stromatolites or by the local quarryman’s term “Caps”.

This presentation reviews their occurrence, facies, early diagenetic fabrics and pore systems and discusses the likely depositional and early diagenetic environments that have resulted in the formation of some remarkably porous rocks.

The Wessex Basin in Late Jurassic times was undergoing extension-related subsidence with maximum accumulation of clastics and carbonates in the hangingwall sub-basins adjacent to east-west trending normal faults (Fig. 1). The palaeoenvironment of the lower Purbeck Limestones is non-marine and succeeds the shallow- marine tropical grainstone shoals of the underlying Portland Limestone.

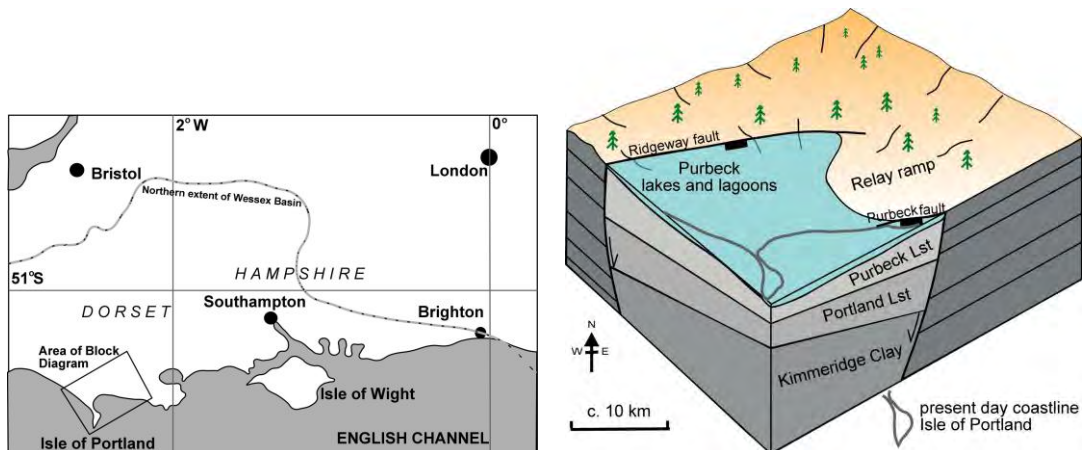


Fig. 1. Locality map (left) showing area of block diagram (right) that interprets the Late Jurassic geological setting of the Purbeck Limestone. The Ridgeway and Purbeck faults are shown in their extensional (pre-inversion) mode and are separated by a soft-linkage relay ramp. Purbeck Limestones accumulated in a lacustrine system in the southern hangingwall sub-basins.

Early workers considered the Purbeck Limestone to be freshwater tufas or tuffaceous limestones (Arkell, 1947) sandwiched as they are between fossil soils. The soils are interpreted to have formed in a seasonally arid (Mediterranean-type) climate setting (Francis, 1984). West (1975) has shown that in many areas the Purbeck limestones show evidence of replacement by sulphate evaporites and interprets the environment as a hypersaline lagoon. More recently Bosence (1987) and Perry (1994) showed that the lower Purbeck Limestones on the Isle of Portland are characterised by microbial mounds likely to be of freshwater in origin and are not associated with primary or secondary evaporates, or their replacements.

The lower Purbeck Limestones show both microbial and precipitated fabrics in the construction of thrombolites and stromatolites. These occur in association with trees to form mounds that are commonly 5-10 m across and 2-3 m high (Fig. 2). The mounds are surrounded by intermound areas that accumulate peloidal, intraclast, skeletal grainstones and rudstones (Fig 2).

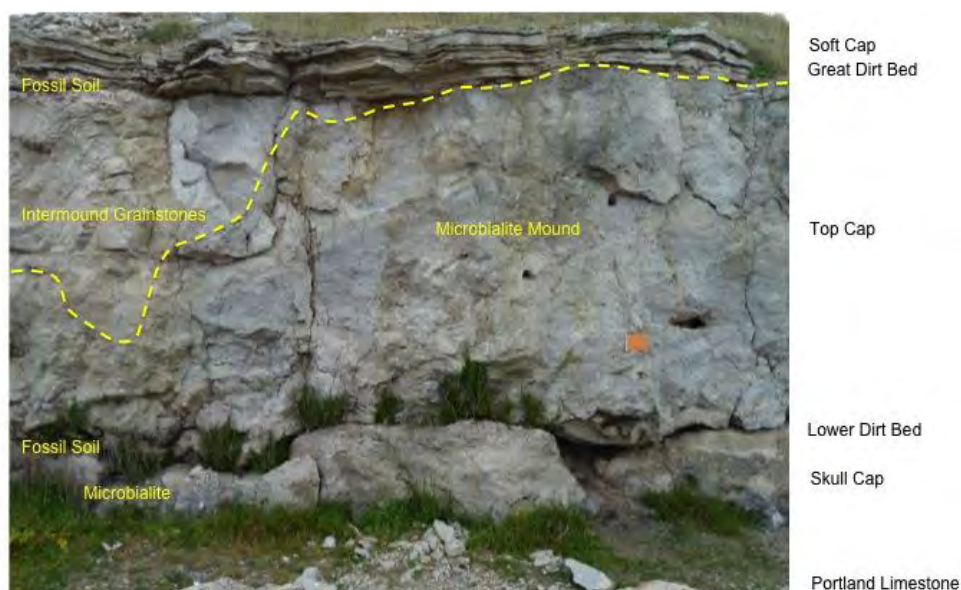


Fig 2. Detail of Purbeck Limestone showing 3 m high quarry section of in situ Mound and bedded Intermound facies sandwiched between two fossil soils (or “Dirt Beds”. “Caps” are the local quarry workers terms for the limestones above the building stones of the Portland Limestones). Isle of Portland.

The microbial facies grew around the bases of the ancestral conifer trees; initially, when they were still upright, and subsequently, when they fell and the microbialites expanded laterally and vertically to form mounds (Fig 2). Two main microbialite facies are recognised (Bosence, 1987):

- 1) Burrowed microbialite forms concentric layers around the trees. Peloidal packstones accumulate as subvertical collars, or sleeves that are locally bound by algal filaments. The packstones are ubiquitously burrowed and burrow morphology and size are remarkably similar to those of modern insect larval tufas.
- 2) Thrombolites form the bulk of the mounds growing over the previous subfacies or expanding laterally to colonise intermound areas. These are complex lithologies with clots and columns constructed by algal filaments trapping and binding peloids and rare skeletal debris of thin-shelled molluscs and ostracods. This framework is

commonly encrusted by early fibrous calcite cement. Cavities are partially infilled with internal peloidal, intraclastic (eroded framework) and skeletal pack- to grainstones. Locally these internal sediments are interlayered with early blocky calcite cements and crystal silts. Up to 20-30% primary framework porosity is preserved in this subfacies. The thrombolites are similar to thrombolites seen in Mono Lake, California where freshwater springs formed columns in a saline lake environment and also in Lake Clifton Australia where groundwater seeps into a brackish lake.

Recent field-work has focussed on mapping of Mound and Intermound facies, and subfacies where appropriate, on vertical quarry faces on the Isle of Portland. Mounds appear sub-circular in plan varying from 1 to 15 m in diameter and are up to 3 m in thickness. Mounds account for 27% of the cross sectional area of outcrops and intermound facies the remaining 73% (O'Bierne, 2011).

The facies indicate a moderate to high energy, non-marine environment for the formation of the mounds and intermound grainstones. The environment appears to have varied laterally from a hypersaline through to brackish and possibly freshwater lacustrine system. Pseudomorphs after sulphate and chloride minerals indicate a coastal marine setting and the conifer trees and soils a seasonal, semi-arid climate. Early, cavity filling cements and crystal silts in the Purbeck Limestones on Portland are interpreted as calcisiltites precipitated from meteoric vadose fluids related to the overlying emergent soil surfaces.

Primary porosity is preserved in both in situ mound facies and intermound grainstones. Mound facies contain framework, burrow, fracture and interparticle pore spaces whilst intermound areas have interparticle, mouldic and fracture pore systems.

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