3D modelling of the lithofacies architecture of the Great Oolite Group in the Cotswold Hills, Gloucestershire, England

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The Great Oolite Group (Bathonian, Middle Jurassic) of the mid Cotswold Hills is a classic example of a limestone-dominated succession deposited on a carbonate ramp, with a range of distinct carbonate and subordinate siliciclastic facies belts which migrated basinward through time. The outcrops have been mapped by the British Geological Survey (BGS) and a number of fully cored boreholes logged in detail. Subsequently, its architecture has been modelled in 3D using the geological modelling software GSI3D (www.gsi3d.org.uk) as cross sections, surfaces and volumes across an area of about 1500 square kilometres which extends up to nine kilometres south-east in the subcrop.

Modelling was carried out using the BGS DiGMap50 digital geological map coverage, a high-resolution Digital Terrain Model (DTM) and borehole data loaded into the GSI3D software. Essential to the methodology is the prior coding of downhole information from boreholes. Cross sections were chosen to traverse outcrops and intersect key boreholes to form a dense grid with a spacing of generally less than 2 km and no more than eight km. Initially lithostratigraphical units (formations and members) and lithofacies were correlated between outcrops and key boreholes, with account being taken of faulting, strata dip, superficial structures and the geologist's knowledge or inferences of patterns of lateral thickness changes and pinch-outs.

Once the units are correlated in cross section, triangulated surfaces are easily calculated, enclosing volumes for each unit. The software allows the model to be simultaneously viewed as a 2D map, one of the cross sections and a 3D image, all in full colour. The 3D image can be rotated, zoomed and exaggerated instantly to allow the geologist to inspect and modify any feature in real time.

Modelling has shown that carbonate mud to sand-grade deposition was centred on the Cotswold-Weald Shelf, with generally modest input of silicate clay, silt or periodically fine-grained sand shed from the low-lying London Platform landmass located to the east. To the south in the Wessex Basin deposition was dominated by silicate mud. Displaying the lithofacies reveals an architecture of stacked carbonate wedges, prograding southwards from the shelf into the basin. This pattern is particularly conspicuous in the ooidal limestone lithofacies deposited by mobile shoals under high-energy, very shallow water conditions close to the shelf edge, which are represented in ascending and southwards-progressing order by the Taynton Limestone, Minchinhampton Limestone, Athelstan Oolite and Chalfield Oolite units. These are generally underlain by bioclastic, fine-grained limestones, interpreted as deposited on the foreslope. Shorewards of the ooid shoals, lime mud with peloids and bioclasts accumulated in protected marine lagoonal environments (White Limestone Formation). These locally contain coralliferous accumulations, some of which are interpreted as patch reefs, but no barrier reefs are known to be preserved.

This approach offers great flexibility, with easy interactive editing of lithofacies correlations. It also promises the opportunity to feed back revised borehole classifications and geological linework based on interpretation of the lithofacies architecture.

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