Chapter 3 The Middle Jurassic stratigraphy of the Cotswolds

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Introduction

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The Cotswold Hills, which extend for approximately 90 km from Bath in Somerset northwards to near Chipping Norton in Oxfordshire (Figure 3.1), are formed of Aalenian–Bathonian rocks. Those of Aalenian–Bajocian age are dominated by ooidal and peloidal, variably shelly limestones that were deposited in a shallow shelf- sea. The shoreline lay to the east and was probably not too far distant, as land marginal facies are present in the East Midlands (see Chapter 4). The overlying Bathonian rocks of the Cotswolds are also predominantly shallow shelf-sea carbonates but, as with the Aalenian–Bajocian strata, a change occurs in the north-east of the area and beyond (see Chapter 4), with brackish-water and freshwater terrigenous sediments indicating a coastal zone of saltmarshes. The Cotswold Hills, which are typified by picturesque villages and drystone walls built of the rich, cream-coloured local Middle Jurassic limestones, gradually peter out in north Oxfordshire and Northamptonshire. This may be partly due to the north-eastwards facies change but is largely due to much later landscaping by Quaternary glaciation and an associated cover of drift deposits.

The Middle Jurassic rocks of the Cotswold area have a long history of geological investigation, and feature prominently in the history of geology itself. William Smith (1769–1839), the so-called 'Father of English Geology', was born in the village of Churchill, *c.* 5 km south-west of Chipping Norton, and spent his early working life surveying in the Cotswolds and surrounding counties. He lived the greater part of his life in and around Bath, which, at the end of the 18th century, was an important centre of social and intellectual activities. In 1799, Smith, with the help of his two friends the Rev. Benjamin Richardson and the Rev. Joseph Townsend, both of whom were collectors of minerals and fossils, recorded the succession of rock units, together with their thicknesses and characteristic fossils, which he had established in and around the Cotswolds. Between then and 1816, following the publication of Smith's great geological map of England and Wales in 1815, this list of stratal names underwent several minor revisions, but the names of Middle Jurassic strata, such as Cornbrash, Forest Marble, Great Oolite and Fuller's Earth and Rock, which originated with William Smith, are still used today (Sheppard, 1917; Cox, 1948). Smith's friend Townsend (1813) is attributed with the first published use of the terms 'Inferior Oolite' and 'Kelloway' (now Kellaways) Rock. Through this early work of William Smith and his companions, the Middle Jurassic rocks and localities in the Cotswolds became known to workers in continental Europe, and the Bathonian and Callovian stages were subsequently named by their Belgian and French authors after Bath and Kellaways respectively (see Chapter 1).

Later in the 19th century, papers by Lonsdale (1832), Murchison (1834, 1845), J. Buckman (1842), Brodie (1851, 1853), Wright (1856, 1860), Witchell (1880, 1882a,b, 1886), Wethered (1891) and S.S. Buckman (1889a, 1890, 1892, 1893a, 1895, 1897, 1901, 1905), as well as [British] Geological Survey memoirs by Hull (1857) and Woodward (1894), provided further details of the local Middle Jurassic succession. The work of Sydney Savory Buckman (1860–1929) is of particular note for he recognized the two major non-sequences that interrupt the Aalenian–Bajocian succession. At these levels, the strata above the non-sequences overlap or overstep the older beds beneath. The episodes of erosion that caused these non-sequences were referred to by Buckman (1901) as the Aalenian and Bajocian denudations. They are marked by eroded, planed and bored, oyster-encrusted hardgrounds. Later, Arkell (1933) used the terms Bajocian and Vesulian transgressions for the renewed deposition that followed the denudations. Authors have generally perceived these two major interruptions in sedimentation as representing periods of tectonic activity during which structures such as the so-called 'Painswick Syncline', 'Cleeve Hill Syncline' and the intervening 'Birdlip Anticline' were formed (Figure 3.2). However, these structures are relatively modest in scale and may rather be the product of more-or-less gentle subsidence with the erosional truncation occurring during periods of relative lowstand (Barron *et al.,* 1997). Buckman (1905) used the non-sequences as the basis of a three-fold subdivision of the Aalenian–Bajocian succession (Lower, Middle and Upper Inferior Oolite) which, until recently, has remained the primary and traditional classification of these beds (see below).

Around the time of Buckman's later work, Linsdall Richardson (1881–1967) wrote a series of papers on the Middle Jurassic strata of this area and two memoirs for the [British] Geological Survey (Richardson, 1904, 1906, 1907b, 1910, 1911a,b, 1929b, 1933, 1935). His later work coincided with that of Gray (1924), Welch (1927) and William Jocelyn Arkell (1904–1958), another major figure in stratigraphical studies of the Cotswolds (Douglas and Arkell, 1928; Arkell, 1931, 1933, 1934; Richardson *et al.,* 1946; Arkell, 1951–1958; Arkell and Donovan, 1952).

Later work on aspects of the Aalenian–Bajocian succession includes that of Parsons (1974a, 1976b, 1979, 1980a,b), Mudge (1978a,b, 1995) and Baker (1981), and on the Bathonian succession that of Green and Donovan (1969), Sellwood and McKerrow (1974), Palmer (1979), Penn and Wyatt (1979) and Sumbler (1984), and unpublished theses by Barker (1976), Bradshaw (1978) and Cripps (1986). [British] Geological Survey memoirs by Cave (1977) and Horton *et al.* (1987) include accounts of the Middle Jurassic successions in the Malmesbury and Chipping Norton districts respectively. More recent Survey work has led to a revised lithostratigraphy for the Aalenian–Bajocian succession (Barron *et al.,* 1997), and revision of the Middle Jurassic strata of the Cirencester district (Sum-bler *et al.,* 2000). In particular, these authors abandoned the use of the terms Lower, Middle and Upper Inferior Oolite in formal lithostratigraphy and replaced them with properly defined formations — Birdlip Limestone, Aston Limestone and Salperton Limestone, respectively. The correlation of the Bathonian succession of the Cotswold area, which displays rapid lateral and vertical lithological and faunal changes as a number of facies belts migrated basinwards with time, away from the London Landmass, is discussed by Wyatt (1996a) and Sumbler (1999).

The current lithostratigraphical scheme for the Middle Jurassic of the Cotswold area divides the succession into two groups — the Inferior Oolite Group overlain by the Great Oolite Group — which are capped by the Kellaways and Oxford Clay formations; the names of these units originated in the time of William Smith (see above). The current lithostratigraphical subdivision of the Inferior Oolite Group shown in (Figure 3.3) follows Barron *et al.* (1997) and is applicable to all of the Aalenian–Bajocian sites described in this chapter with the exception of the Dundry Hill outlier, in the extreme southwest where, for the time being, the nomenclature follows Parsons (1979, 1980a). In the extreme north-east of the Cotswold area, the lowest beds of the Inferior Oolite Group are replaced by the Northampton Sand Formation and much of the rest is missing owing to non-sequence. Lithostratigraphical subdivision of the Great Oolite Group (Figure 3.4) is more complicated. Although the relationships between the successions in the northern and southern halves of the area are broadly understood, some problems remain in rationalizing the associated lithostratigraphical nomenclature between the areas, and agreeing an appropriate and consistent usage.

Apart from the Inferior Oolite Group of Dundry Hill, ammonites in the Aalenian to Bathonian interval in the Cotswolds are generally sparse and are unknown in some formations and members; nonetheless, they enable the various lithostratigraphical units to be placed, with a moderate degree of confidence, within the ammonite-based chronostratigraphical framework. For the Aalenian–Bajocian strata, this is based essentially on Parsons (1980a), as modified by Callomon and Chandler (1990) and Callomon (in Callomon and Cope, 1995); and for the Bathonian Stage, on Torrens (1980b), as modified by Callomon (in Callomon and Cope, 1995) and Page (1996a). Only the Lower Callovian Substage is referred to in this chapter, for which the chronostratigraphical framework follows Callomon *et al.* (1989) and Page (1989). The highly ammonitiferous beds of Dundry Hill have enabled recognition of some of the ammonite biohorizons of Callomon and Chandler (1990) as modified by Callomon (in Callomon and Cope, 1995; see also Chapter 1). For the Bathonian Stage, apparently quasi-isochronous event horizons (Wyatt, 1996a) provide the potential for the development of a reliable chronostratigraphical framework into which the scattered ammonite occurrences may be fitted. The most important of these event horizons are the *Praeexogyra acuminata*-rich beds and Echinata Bed in the Fuller's Earth Formation, the Excavata, Langrunensis, Ardleyensis and Bladonensis beds in the White Limestone Formation, and the bases of the Forest Marble and Cornbrash formations.

Details of the main lithologies and depositional environments are included in the site descriptions that follow. In the following list of sites (arranged south to north), (A) indicates that the site belongs to the Aalenian–Bajocian GCR Block, (B) indicates the Bathonian GCR Block and (C) the Callovian GCR Block. The location of the sites is shown in (Figure 3.1).

Barns Batch Spinney, Somerset (A)

South Main Road Quarry Somerset (A)

Brown's Folly, Somerset (B)

Corsham Railway Cutting, Wiltshire (B)

Kellaways–West Tytherton, Wiltshire (C)

Lower Stanton St Quintin Quarry and Stanton St Quintin Motorway Cutting, Wiltshire (B)

Hawkesbury Quarry Gloucestershire (A)

Nibley Knoll, Gloucestershire (A)

Veizey's Quarry, Gloucestershire (B)

Kemble Cuttings, Gloucestershire (B)

Woodchester Park Farm, Gloucestershire (B)

Minchinhampton, Gloucestershire (B)

Leigh's Quarry, Gloucestershire (A)

Fort Quarry Gloucestershire (A)

Haresfield Hill, Gloucestershire(A)

Frith Quarry Gloucestershire (A)

Swift's Hill, Gloucestershire (A)

Knap House Quarry, Gloucestershire (A)

Crickley Hill, Gloucestershire (A)

Leckhampton Hill, Gloucestershire (A)

Foss Cross, Gloucestershire (B)

Stony Furlong Railway Cutting,

Gloucestershire (B)

Rolling Bank Quarry, Gloucestershire (A)

Hampen Railway Cutting, Gloucestershire (B)

First Cutting West of Notgrove, Gloucestershire (A)

Harford Cutting, Gloucestershire (A)

Huntsmans Quarry, Gloucestershire (B)

Jackdaw Quarry, Gloucestershire (A)

Snowshill Hill (Hornsleasow Quarry), Gloucestershire (B)

Cross Hands Quarry, Warwickshire (A)

Sharps Hill, Oxfordshire (B)

Hook Norton, Oxfordshire (B)

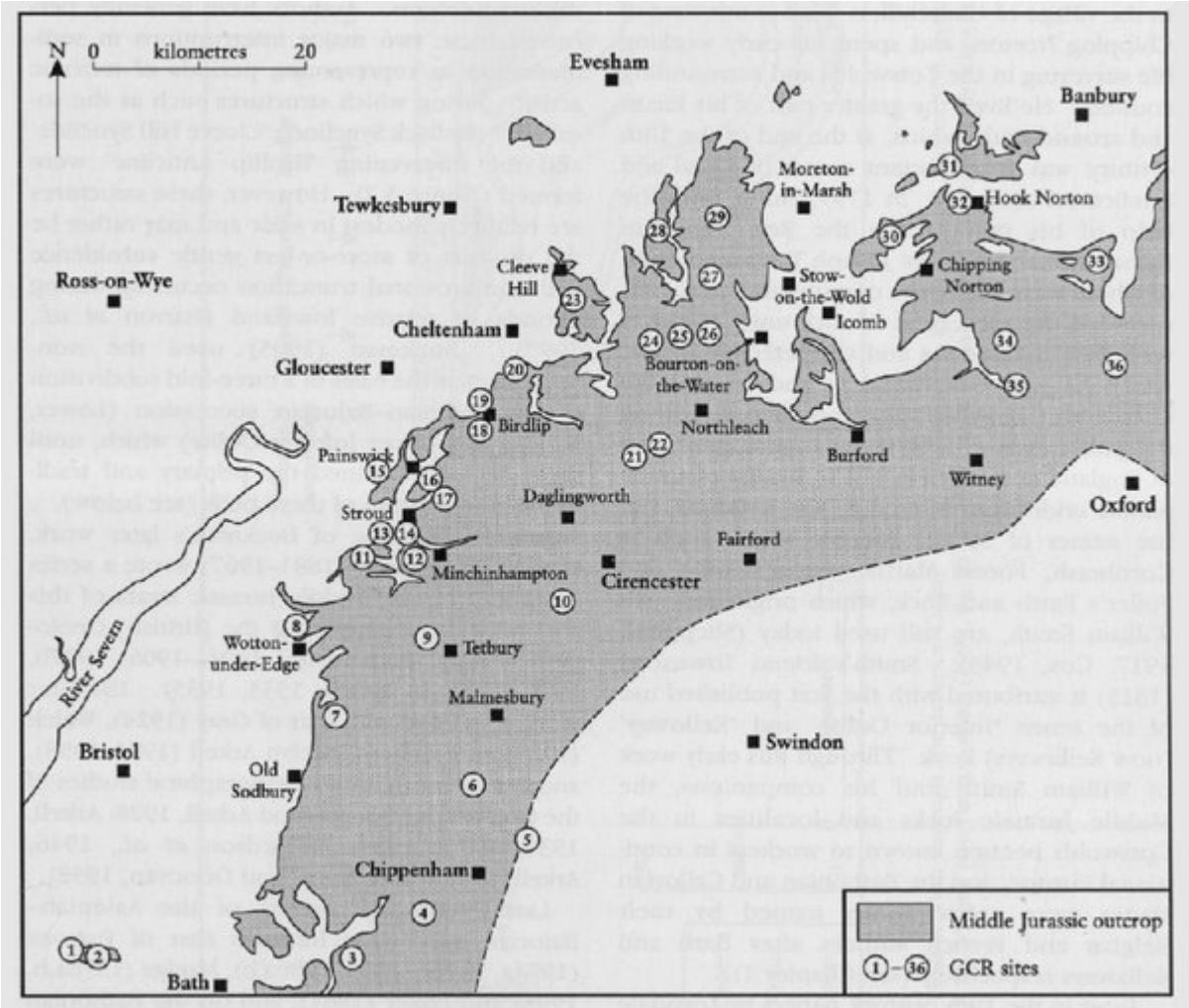
Horsehay Quarry, Oxfordshire (B)

Ditchley Road Quarry, Oxfordshire (B)

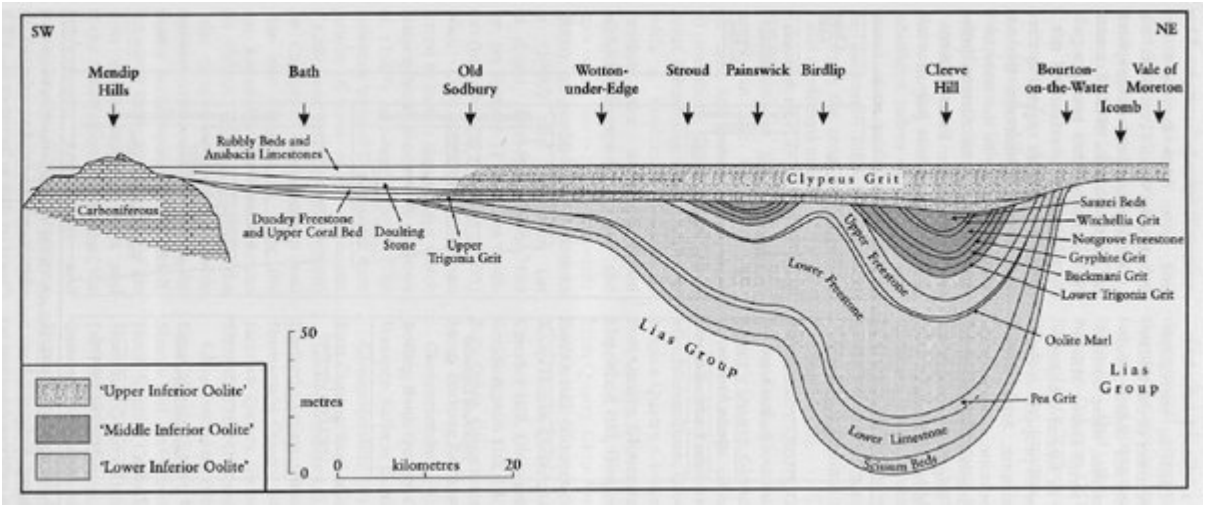
Stonesfield, Oxfordshire (B)

Shipton-on-Cherwell Cement Works and Whitehill Farm Quarry Gibraltar, Oxfordshire (B)

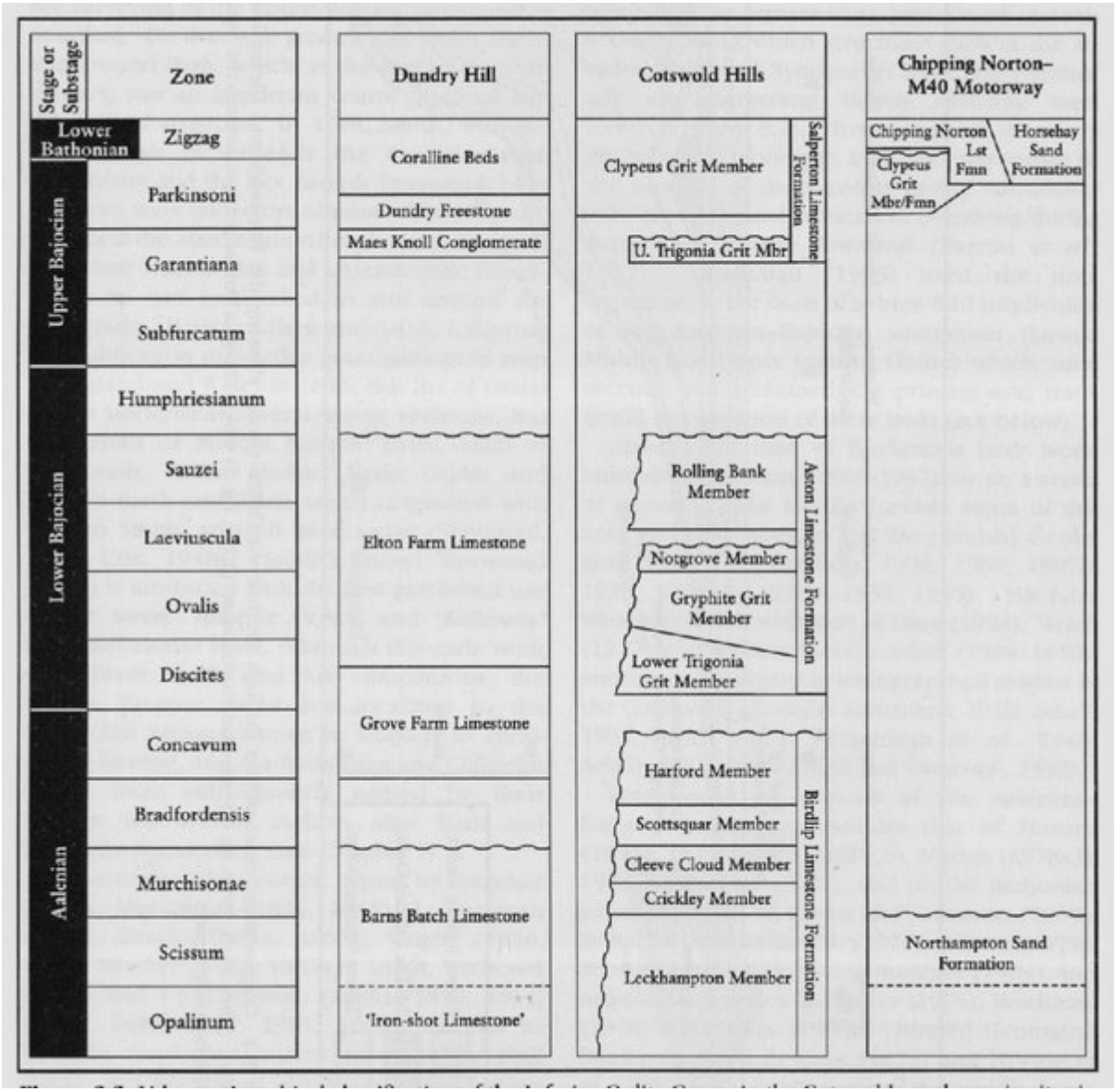
References



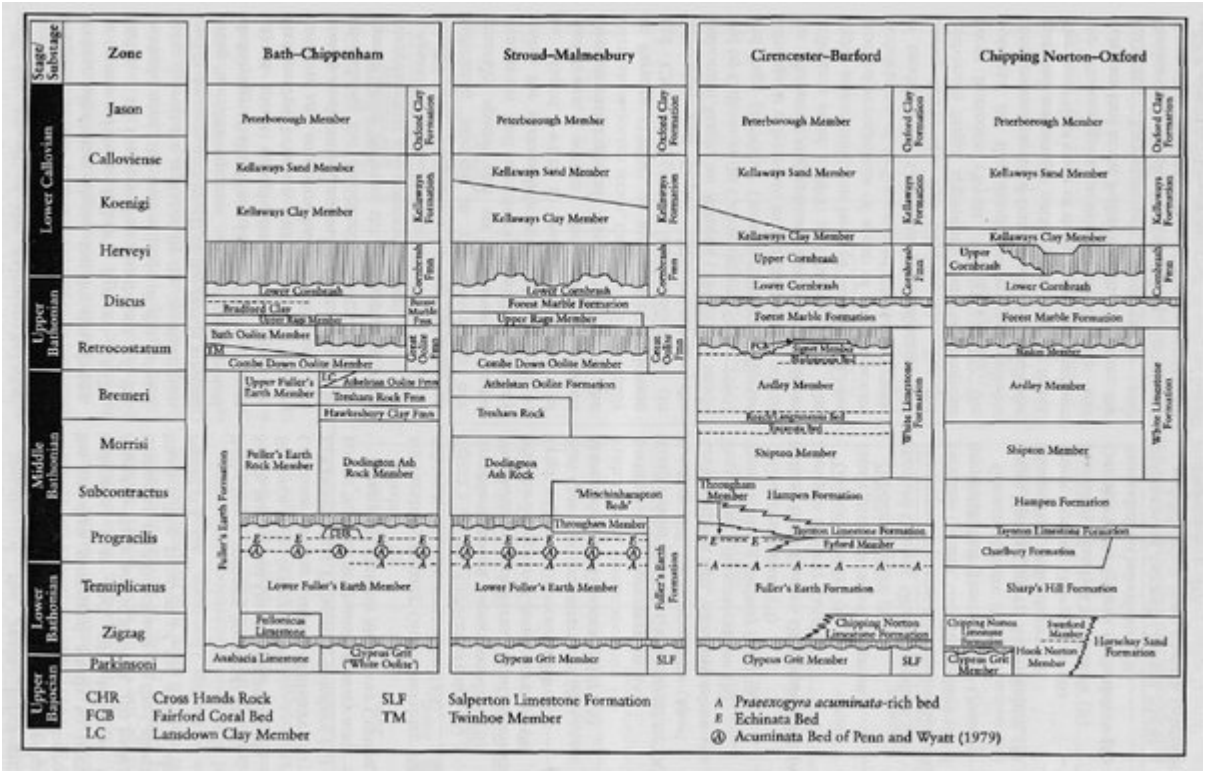
(Figure 3.1) Geological sketch map showing the location of the GCR sites described in Chapter 3. (1) Barns Batch Spinney; (2) South Main Road Quarry; (3) Brown's Folly; (4) Corsham Railway Cutting; (5) Kellaways–West Tytherton; (6) Lower Stanton St Quintin Quarry and Stanton St Quintin Motorway Cutting; (7) Hawkesbury Quarry; (8) Nibley Knoll; (9) Veizey's Quarry; (10) Kemble Cuttings; (11) Woodchester Park Farm; (12) Minchinhampton; (13) Leigh's Quarry; (14) Fort Quarry; (15) Haresfield Hill; (16) Frith Quarry; (17) Swift's Hill; (18) Knap House Quarry; (19) Crickley Hill; (20) Leckhampton Hill; (21) Foss Cross; (22) Stony Furlong Railway Cutting; (23) Rolling Bank Quarry; (24) Hampen Railway Cutting; (25) First Cutting West of Notgrove; (26) Harford Cutting; (27) Huntsmans Quarry; (28) Jackdaw Quarry; (29) Snowshill Hill (Hornsleasow Quarry); (30) Cross Hands Quarry; (31) Sharps Hill; (32) Hook Norton; (33) Horsehay Quarry; (34) Ditchley Road Quarry; (35) Stonesfield; (36) Shipton-on-Cherwell Cement Works and Whitehill Farm Quarry.)



(Figure 3.2) Diagrammatic cross-section through the Inferior Oolite Group showing the Painswick and Cleeve Hill 'synclines', and the intervening 'Birdlip Anticline'. (After Akell, 1933, fig. 35; see also Barron et al. (1997, fig. 5) which shows a similar section through the 'synclines' based on more recent data and with revised lithostratigraphy.))



(Figure 3.3) Lithostratigraphical classification of the Inferior Oolite Group in the Cotswolds as shown in sites in Chapter 3. Columns are deliberately separated one from the other because of complexities of correlation and non-sequence. Vertical ruling indicates non-sequence. (Based on data in Barron et al., 1997; Parsons, 1979, 1980a; and Wyatt in Sumbler, 1996.))



(Figure 3.4) Lithostratigraphical classification of the Great Oolite Group and overlying beds in the Cotswold area. Columns are deliberately separated one from the other because the nomenclature as used in different areas is in need of rationalization. Vertical ruling indicates non-sequence. (Based on data in Cave, 1977; Horton et al., 1987; Page, 1989, 1996a; Sumbler et al., 2000; Wyatt in Sumbler, 1996; and herein.))