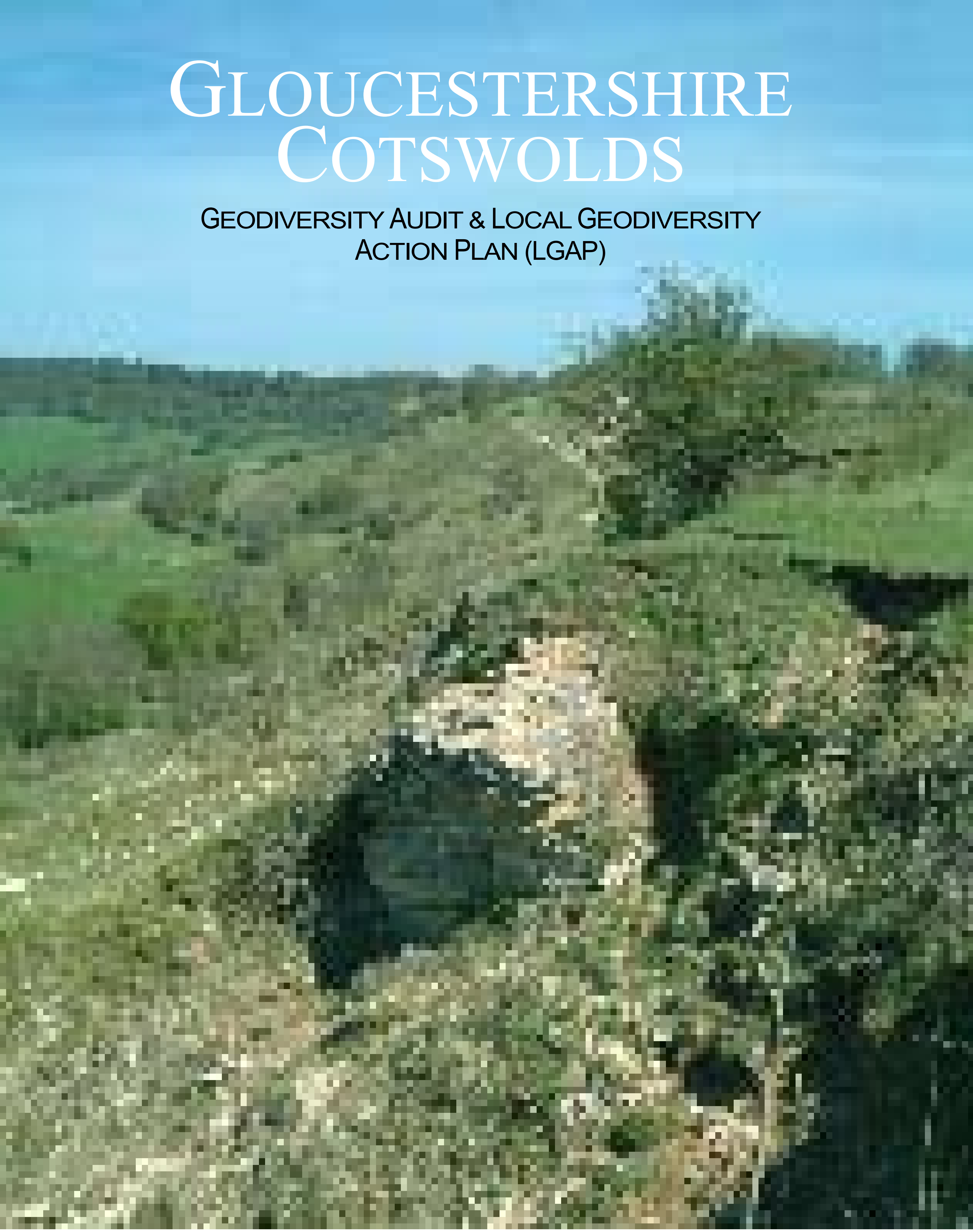
Gloucestershire Cotswolds

Geodiversity Audit & Local Geodiversity Action Plan (LGAP)



2005

The Geology Trusts

Gloucestershire Geoconservation Trust

GLOUCESTERSHIRE COTSWOLDS

GEODIVERSITY AUDIT & LOCAL GEODIVERSITY ACTION PLAN (LGAP)

Prepared by Gloucestershire Geoconservation Trust in partnership with:

The Geology Trusts
Cotswolds AONB Conservation Board
IHS Energy Ltd.

Principal Authors:
David Owen
Bill Price
Claire Reid

With contributions from:
Hannah Evans, Nick Chidlaw, Chris Toland, and John Conway

This Geodiversity Audit and Local Geodiversity Action Plan (LGAP) has been prepared by Gloucestershire Geoconservation Trust, in partnership with The Geology Trusts, Cotswolds Area of Outstanding Natural Beauty Conservation Board and IHS Energy Ltd., with funding from the Aggregates Levy Sustainability Fund (ALSF) administered by the Minerals Industry Research Organisation (MIRO) via the Office of the Deputy Prime Minister.

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ISBN 1-904530-07-9

Bibliographical Reference:
Owen, D., Price, W. and Reid, C. 2005. Gloucestershire Cotswolds: Geodiversity Audit & Local Geodiversity Action Plan. Gloucester: Gloucestershire Geoconservation Trust.

Cover photograph: The Cotswold Escarpment Between Crickley Hill and Shurdington Hill

Lists of sites in this document have been compiled from records in the Gloucestershire Geological Records Centre. Sites have been selected for their representitiveness and geological merits. Their listing implies no right of access and in all instances access must be arranged in advance with the appropriate landowner.

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Printed by Impressions of Monmouth Ltd. 01494 839407

Contents

SECTION 1 INTRODUCTION TO THE GLOUCESTERSHIRE COTSWOLDS LOCAL GEODIVERSITY ACTION PLAN

SECTION 2 GEODIVERSITY IN THE GLOUCESTERSHIRE COTSWOLDS

SECTION 3 GEODIVERSITY AUDIT

SECTION 4 IMPLEMENTING THE ACTION PLAN INTERPRETING GEODIVERSITY

FIGURES

Section 1 Figures

Section 3 Figures.

TABLES

Section 3 Tables.

Section 4 Tables.

SECTION 1

THE GLOUCESTERSHIRE COTSWOLDS

SECTION 1 THE GLOUCESTERSHIRE COTSWOLDS

1.01 Introduction

The Cotswold Hills stretch for nearly 60 miles, forming part of an outcrop of Jurassic rocks that runs NE from the Dorset coast to the North Sea off Yorkshire. The steep western scarp of the Cotswolds exposes sections through Lower and Middle Jurassic rocks that dip gently eastwards towards Oxford and London. At Leckhampton Hill and Cleeve Common the thickest sections of Jurassic Inferior Oolite rocks anywhere in the country are found, and unique strata exposed, a feature recognised by their designation as Sites of Special Scientific Interest.

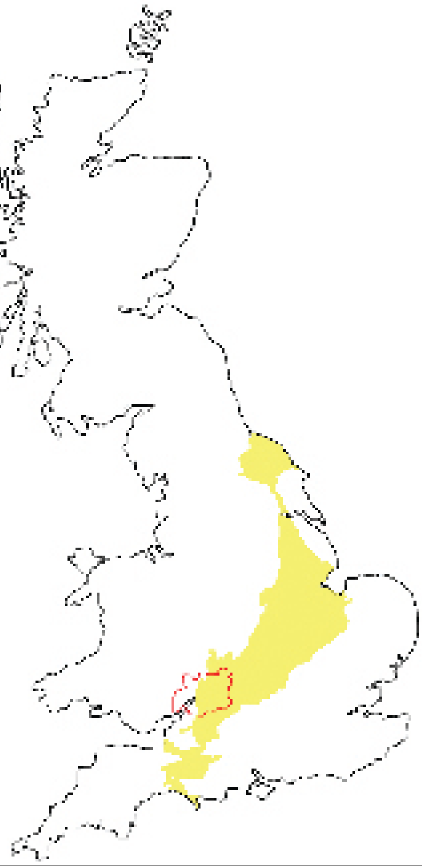
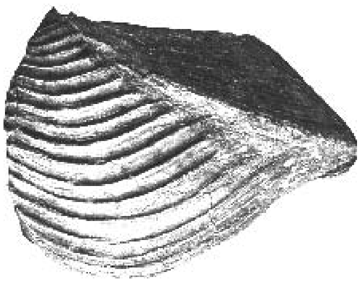


***Fig.1.1* The main outcrop of Jurassic rocks in Britain with Gloucestershire outlined in red**

***Ampullospira cincta* (Gastropod)**

***Plectothyris fimbria* (Brachiopod)**

***Trigonia costata* (Bivalve)**



The geology of the Cotswolds has a very strong influence on the landscape, vegetation and wildlife, as well as on the industry and heritage. The soils and vegetation noticeably change as the underlying geology changes from one type of rock to another, influencing growth of different species of plants and trees, which in turn provide habitats for a variety of different animal and bird species.

The rocks that form the Cotswold Hills are made up of three different geological stages of the Jurassic period and date from between 210-140 million years ago. The Lower Jurassic is made up of the Lias Group; the Middle Jurassic Rocks include the Inferior Oolite Group, and the younger Great Oolite Group; the transition between the Middle and Upper Jurassic rocks is marked by the Kellaways Beds and Oxford Clay Formations. Each Group is subdivided into Formations and Members, distinguished from each other according to differences in the constituent parts of the rock, the types of fossils found in the rocks and by erosional surfaces that mark breaks in deposition of the sediments.

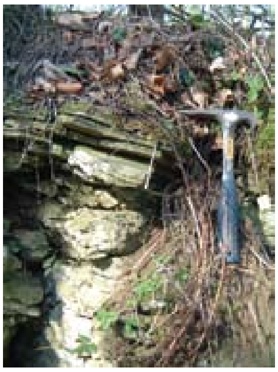
***Clypeus ploti* (Echinoid)**

***Cercomya undulata* (Bivalve)**

Geodiversity is the natural range (diversity) of geological (rocks, minerals, fossils, structures) geomorphological (landforms, processes) and soil features. It is the variety of geological environments, phenomena and processes that make those landscapes, rocks, minerals, fossils and soils that provide the framework for life on Earth. It includes their relationships, properties, interpretations and systems and the links between landscapes, people and culture.

The Cotswold Escarpment at Crickley Hill

Geological features include the rocks themselves, plus the minerals, fossils and structures found in them. Rock types can vary greatly within a very short distance, each change representing changes in the environmental and depositional conditions and processes over time. Different minerals can be found dispersed throughout the rocks and in concentrations within the rocks. Whether part of original sediment, altered during lithification or emplaced after the rock has formed, minerals also have an important story to tell.



Cotswold Slates (Eyford Member)

Perhaps the best known and easily recognised features of geodiversity, apart from the landscape itself, are fossils. Fossils can be the remains of animals, plants, soils and even landforms and are one of the most powerful interpretive tools in Earth science, as well as one of its most popular and appealing aspects. There are also a vast array of structures to be found in the rocks, from features produced during deposition such as sand volcanoes and tool marks, to features post-dating deposition such as folds, faults and caves.

A 'gull' on Crickley Hill caused by cambering on the escarpment widening joints in the limestones

Geomorphological features are those that produce the shape and form of the land we see on the surface. Geomorphology looks at the results of weathering and erosion, the action of rivers, glaciers and wind, and can provide evidence of more recent crustal instability, landslides and earthquakes. Soils are formed as a direct result of weathering of the underlying rock and, as such, mirror many of the properties of the rocks. They consist of particles of the weathered rock, mixed with the biological remains of plants and animals, and are where the worlds of biodiversity and geodiversity meet head-on.

Dry stone walls are a familier part of Cotswolds geodiversity

Geological resources have played a significant role in social and economic development for thousands of years. The location of different minerals and their ease of availability, from flint during the Stone Age to coal in the industrial revolution, have driven the initiation and development of settlement and industry.

The Devils Chimney, a quarrymans folly on Leckhampton Hill, now suffering badly from erosion

1.03 What is a Geodiversity Action Plan and What is Its Purpose?

The variety of natural features and processes and their value to social, economic, scientific, educational and aesthetic issues needs to be fully and widely understood in order for effective long term and sustainable geoconservation to take place, An all-encompassing approach to nature conservation is needed in order to fully understand the systems operating in the natural world, and to learn from past events so that future management recommendations can be made with increased accuracy and confidence. One of the main purposes of a Geodiversity Action Plan is to repair the imbalance between the biotic and abiotic in nature conservation policy and to raise awareness of the importance of geodiversity in the management of the environment.

All geological features are vulnerable to a variety of factors, both man-made and natural, including man-made interference from development, landfill and fly-tipping, plus natural processes such as overgrowth of vegetation and natural erosion that would not be accepted at equivalent sites of biological or archaeological importance. This Geodiversity Action Plan aims to confront these threats and to develop management practices and sustainable mechanisms for developing, supporting and sustaining geodiversity.

Raising awareness of the importance of geodiversity has a major role to play in sustaining and managing a high quality resource, especially amongst landowners, but also with the general public.

1.04 Geoconservation

Humans have exploited the Earth's natural resources for thousands of years, Gloucestershire being no exception. Iron ore, coal, clay, aggregates and the famous Cotswold Limestones are still extracted within the county. All of these activities plus numerous natural landforms have created many geological exposures, as have road, railway and canal cuttings.

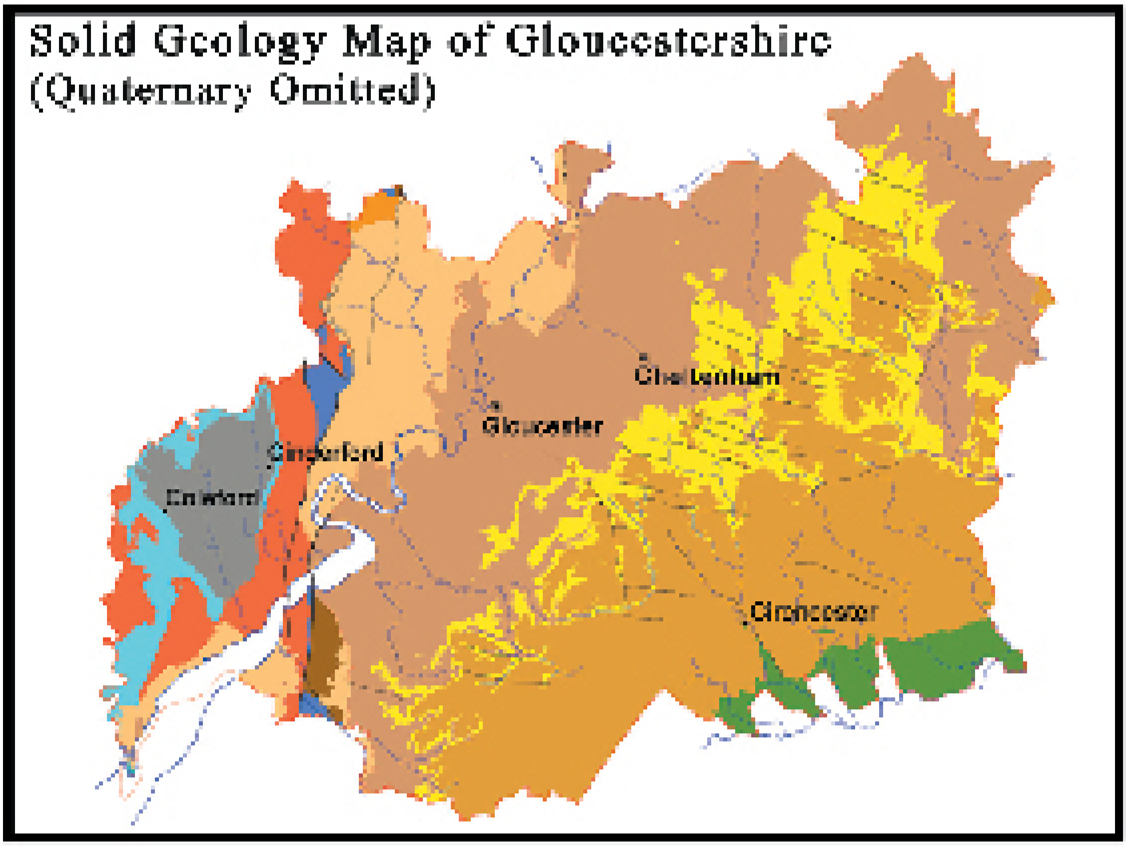
Many of these sites are so important nationally and internationally that they are protected by law, through designation as Sites of Special Scientific Interest (SSSI). Other sites that are important to regional geology are identified as Regionally Important Geological / Geomorphological Sites (RIGS).

Although these sites would at first appear to be permanent, robust and requiring no looking after, they can be damaged, destroyed or lost all together by inappropriate development or use, landfill, fly tipping or through numerous natural processes. Site identification, suitable long-term site management plans, publicity and interpretation aims to raise public awareness of the geodiversity within the county and the need to protect it for future generations to enjoy.

Rolling Bank Quarry, Cleeve Common;
a geological Site of Special Scientific Interest within a larger, biological SSSI

The geodiversity within the county has had a very strong influence on its landscape, vegetation and wildlife, as well as on industry and heritage. Gloucestershire contains some of the most varied geology within the U.K. This has given rise to a wide range of scenic features for which the county is renowned, including the escarpment of the Cotswolds, the Forest of Dean, May Hill, the deep gorge of the Wye Valley and the low-lying area of the Severn Vale. The county is split roughly into two parts, both physically and geologically, by the River Severn. To the west lie thick sequences of Palaeozoic rocks, while those to the east are composed of younger Mesozoic sediments, predominantly Jurassic in age, with some older rocks dispersed therein.

The climate and landscape of Gloucestershire has not always been as we know it today, It has experienced many fluctuations in sea level and climate between 'ice house' and 'green house'. Through geological time, Gloucestershire has seen active volcanoes, mountains rise and be eroded; it has been covered variously with deep seas, shallow warm seas, hot deserts and ice. The changes in ancient environments and the associated rock types seen today, combined with past and current physical processes has produced the diversity of scenery and landscapes that can be seen in Gloucestershire.



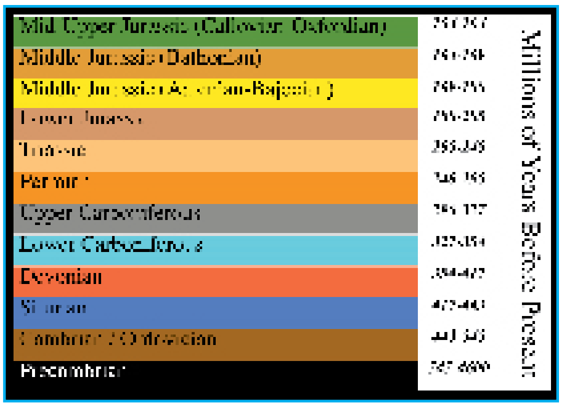


Fig. 1.2
Simplified map of the diversity of solid geology in Gloucestershire

1.06 A Vision for Geodiversity in the Gloucestershire Cotswolds

The Gloucestershire Cotswolds LGAP is intended to:

- Protect and manage the unique geodiversity
    - o A complete stratigraphic sequence of Cotswold rocks will be exposed and demonstrable in the area and a variety of educational and interpretive materials will have been provided. The most important of the sites, the SSSI and RIGS, will be protected and conserved, and plans for their ongoing management and conservation produced, along with interpretation of their features of interest.
    - o Initiatives and opportunities to develop and sell distinctive, high quality “Cotswold” products will have been developed, based on the culture and traditions of the area and using only sustainable sources and land management. These products will be marketed throughout the area and in other suitable locations regionally and nationally.

- Increase understanding and awareness of geodiversity
    - o General interpretation materials will bring together various characteristic features of Cotswolds’ geodiversity and its links with biodiversity, industry, archaeology and history.
    - o The value and importance of geodiversity in the Gloucestershire Cotswolds will be well understood by the people living and working in the area, and its value to tourism will be widely appreciated. People will understand the influence of geodiversity on the historic and economic development of the Cotswolds.

- Promote geotourism, education and lifelong learning
    - o People of all abilities and from all backgrounds will be able to explore the area’s geodiversity, either as part of organised groups and tours, or independently using the interpretation material available.
    - o Specific tours and guides related to the Cotswolds Earth heritage will run alongside other countryside/ natural history tours and guides and will provide high quality holidays.
    - o Accommodation providers and tour operators will be aware of the geodiversity and will promote it as an added attraction to the area.
    - o Imaginative and informative educational visits and opportunities for learning will have been developed and put in place, which will contribute to the local economy. Many educational visits will be run out of peak season, so extending the visitor season and contributing further to the local economy.

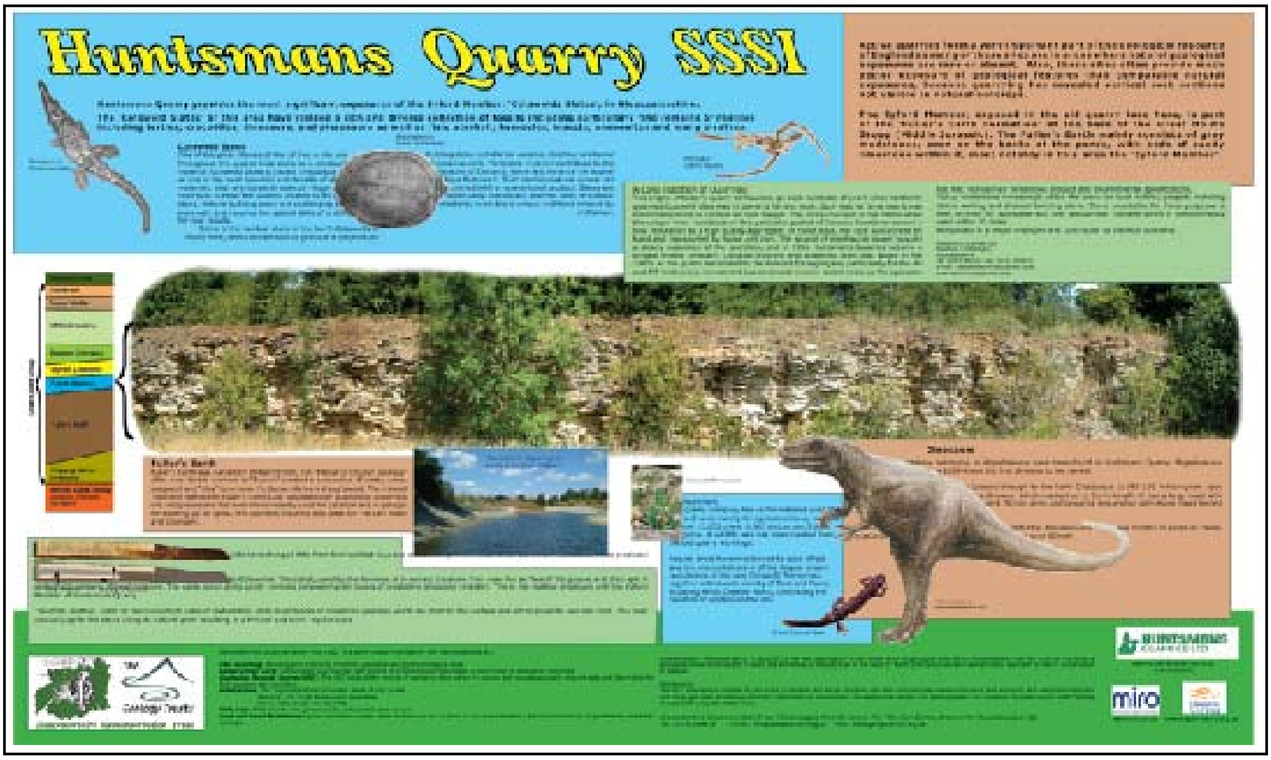


Fig. 1.3
One of the interpretation boards designed for Huntsmans Quarry SSSI as part of the initial LGAP project.
Providing more interpretation such as this is a major part of increasing awareness, understanding, education and tourism related to geodiversity

a. Gloucestershire Geoconservation Trust

Gloucestershire Geoconservation Trust (GGT) is a non-profit making group, a founder member of The Geology Trusts and one of the leading geoconservation organisations in the country. The Trust works in partnership with many other organisations, and the principal aim is to publicise and promote the geological heritage of Gloucestershire, and to raise awareness of the need for its conservation. GGT was set up in 1992 under the Nature Conservancy Council Regionally Important Geological and Geomorphological Sites scheme or "RIGS".

Geoconservation work in the Cotswolds

The Trust does far more than just identify, survey and record sites. GGT also actively restores, enhances and maintains important geological sites, both SSSI & RIGS; keeps an extensive database of geological and geomorphological information; publishes guides and booklets and offers a variety of events throughout the year. In addition to these services, GGT delivers advice and information relating to geology and geoconservation matters, as well as being the key point of specialist Earth heritage conservation advice in the county.

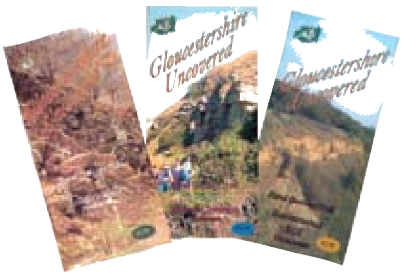


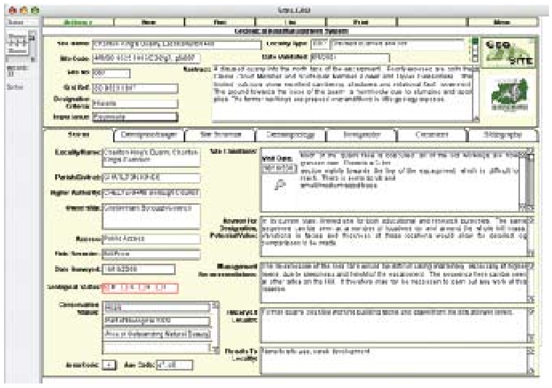
Fig. 1.4
Some of the trail guides published by GGT

The staff, committees, membership and supporters of the Trust consists primarily of volunteers. Containing professional geologists from industry and academia, amateur geologists and local, non-specialist people living within the county, all those involved contribute directly to conserving Gloucestershire's Earth heritage.

b. The Gloucestershire Geological Records Centre (GGRC)

The Geological Records Centre for Gloucestershire was established in 2003 at the GGT offices at Brockworth. All the site records for Geological Conservation Review sites, SSSIs and RIGS form the basis of the data, but is supplemented by records of other local sites, a diverse library and the collections of the Proceedings of the Geologists Association and the Cotteswold Naturalists' Field Club.

Fig. 1.5
Geosites Database screenshot



In 2002, work started on production of a multi-platform digital database of sites and records in order to improve the efficiency of data retrieval. This has now been completed. The software holds all the site survey information, the status of the site, ownership and accessibility information, photographs and links to relevant literature. The 'Geo-Site' database is able to produce reports in a variety of formats, from site-specific reports, to distribution of lithologies and the locations of use and provenance of important building stones. A programme of site monitoring has been established, ensuring up to date and accurate information is available for all sites.

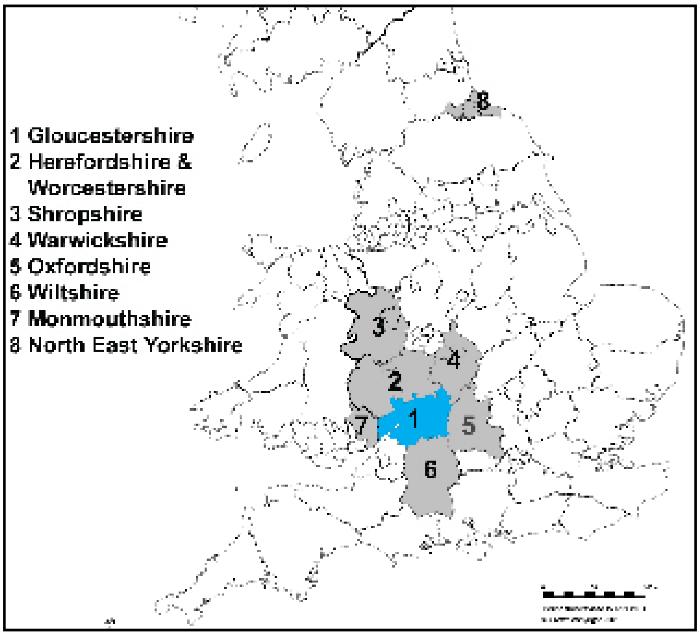
The Geological Records Centre is staffed by fully-qualified geologists, always willing to help with enquiries from organisations and the general public. The data is an extremely valuable resource for the study and preservation of geodiversity and is potentially invaluable scientifically, educationally and commercially.

c. The Geology Trusts (GT)

The Geology Trusts launched in England and Wales in 2003, and currently comprises seven of the leading county based Geoconservation and Earth Heritage Trusts: Gloucestershire, Herefordshire and Worcestershire, Oxfordshire, Shropshire, Warwickshire, Wiltshire and North-East Yorkshire.

It became apparent that making significant advances in the conservation and promotion of Earth heritage cannot continue with part-time (though enthusiastic), input from weekend geologists. Groups needed to take a lead from wildlife organisations, and work with independent offices and paid staff. Currently, GT members utilize over 16 paid staff, allowing for a regular level of service, not only to fund contract programmes but also to members of the groups, local agencies local government authorities and, most importantly, the public!

Fig. 1.6 Geology Trusts in Britain in 2005



d. English Nature (EN)

English Nature has identified the Cotswolds as one of its ‘Natural Areas’ covering an area running NE from Bath to south-east Warwickshire. English Nature’s vision is to sustain and improve the wildlife and natural features of England for everyone. Natural Areas provides a way for all local interests to determine priorities for nature conservation, based on areas with ecological and landscape integrity, and to set objectives which reflect these priorities. Together, Natural Areas provides a powerful vision for nature conservation right across England.

Designation of a site as a SSSI (Site of Special Scientific Interest) gives legal protection to the best sites for wildlife and geology in England. English Nature now has responsibility for identifying and protecting all SSSI’s in England, by law.

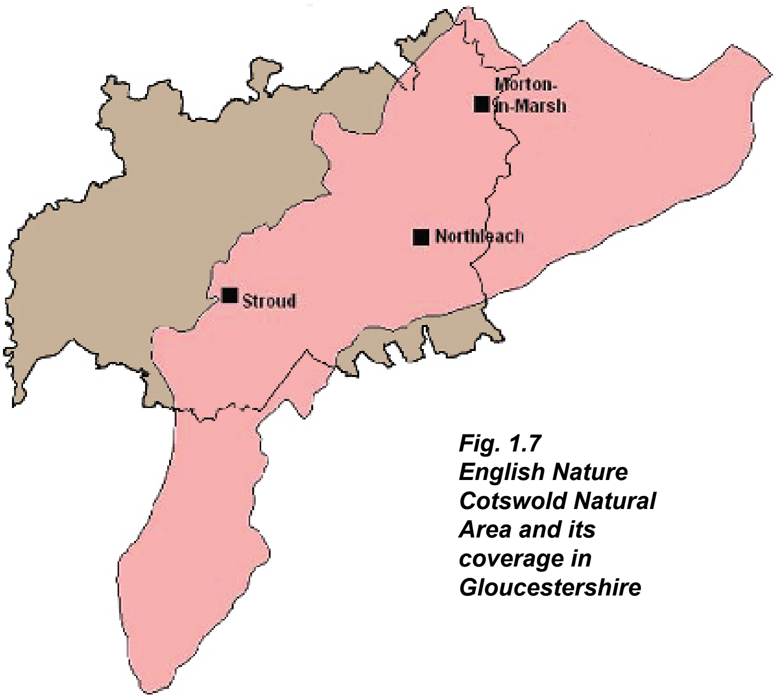


Fig. 1.7 English Nature Cotswold Natural Area and its coverage in Gloucestershire

e. Geological Conservation Review Series (GCR)

A major initiative to identify and describe the most important geological sites in Britain began in 1977, with the launch of the Geological Conservation Review Series (GCR). The GCR was designed to identify those sites of national and international importance needed to show all the key scientific elements of the Earth heritage of Britain. These sites display sediments, rocks, fossils, and features of the landscape that make a special contribution to our understanding and appreciation of Earth science and the geological history of Britain.

In total there are 36 GCR sites within the AONB area, all of which are also designated as SSSI. The sites display a wide range of features and the majority of the sites represent British Jurassic Stratigraphy from the Toarcian to the Bathonian stages of the Early and Middle Jurassic. Also included are sites representing GCR blocks; Jurassic-Cretaceous Reptillia, Mesozoic Palaeobotany, Palaeoentemology, Mesozoic-Tertiary Fish/Amphibia, the Quaternary of Midlands-Avon, Mass Movement and Fluvial Geomorphology of England.

1.08 Cotswolds Area of Outstanding Natural Beauty (AONB)

The Cotswolds became an Area of Outstanding Natural Beauty in 1966. Being an AONB means that the Cotswolds are protected as a very special area of national importance for everyone to enjoy. It is one of 41 AONBs in England and Wales and is the largest, covering 790 sq miles (2,038 sq kms) and is 78 miles (126 kms) from north to south.

Cotswolds AONB Conservation Board

In 2002, the Government passed the Countryside and Rights of Way (CROW) Act which refers specifically to the management of Areas of Outstanding Natural Beauty. As a result of the CROW Act, it was proposed that independent Conservation Boards be created. A Conservation Board is a statutory body, which can make its own decisions, within carefully prescribed limits, without having to refer to each constituent organisation, as was previously the case.

The Cotswolds Conservation Board works with others to conserve and enhance the natural beauty of the AONB and is the only organisation to look after the AONB as a whole. The Conservation Board replaced the AONB Partnership in December 2004. The Board develops and tests new ideas and initiatives for caring for the AONB. It raises awareness of and support for the AONB and aims to reach all those who live and work in the Cotswolds, as well as those who come to visit. The Cotswolds Conservation Board has a small team of staff based at Northleach, a market town at the heart of the Cotswolds AONB.

The Landscape Character Assessment for the Cotswolds area was commissioned by The Cotswold Area of Outstanding Natural Beauty (AONB) Partnership and the Countryside Agency and was published in April 2004 (Cotswolds AONB, 2004). The assessment provides a detailed review of the landscape in the Cotswolds AONB and covers all aspects of landscape in the area. Following on from the assessment, the AONB produced a strategy and guidelines providing an overview of the forces for change that are influencing the landscape and outlined a series of landscape and land management strategies to help guide change in a positive and sustainable way. The assessment included a description of the physical, biological and cultural attributes of the landscape.

1.09 Cotswold Hills Geopark

The process of establishing a Geopark is underway, in order to recognise the significance and importance of the area's geology and landscape. A Geopark is an area containing geological heritage of international significance. The Cotswold Hills Geopark will fall within part of the Cotswolds AONB, although the definitive boundary has yet to be decided. The Geopark aims to focus on a sustainable strategy, primarily through geotourism, education-based programmes, visitor centres, guided walks and museum exhibitions.

The area was chosen to encompass a representative section of geology found in the Cotswolds, within relatively small distances. Exposures of Jurassic Inferior Oolite Rocks found on Leckhampton Hill and Cleeve Common are the thickest in the country and also contain large scale sedimentary structures that are amongst the best in Britain and, indeed, the world. The area also contains other internationally important sites. For example the Jurassic vertebrate fauna found in Hornsleasow Quarry are extremely rare elsewhere, but occur in abundance at this site.

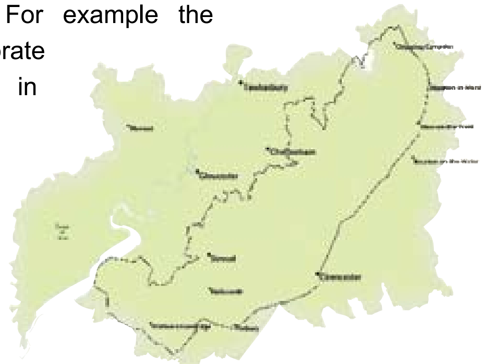


Fig. 1.9
Proposed Cotswold Hills Geopark boundary

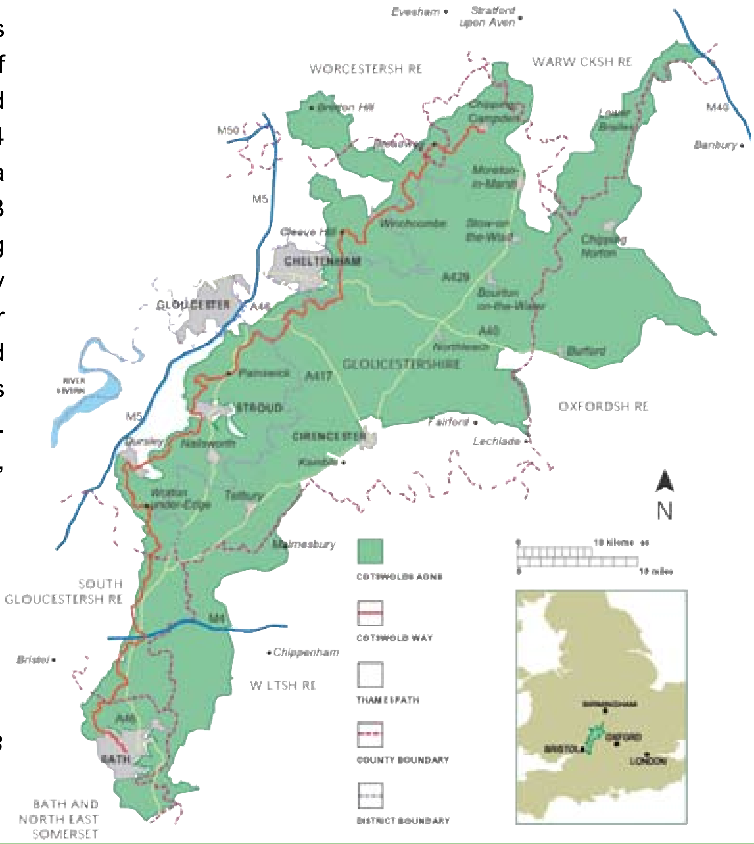


Fig. 1.8 The Cotswolds AONB

The Cotteswold Naturalists' Field Club was established in 1846 and is arguably one of the oldest clubs of its kind in England. The Club began with 25 Foundation Members and by the end of 1846 the number had increased to thirty- seven. In 1907 it was agreed that visitors might include ladies and 1920 saw a new chapter in the clubs history, which sanctioned the admittance of female members. By 1845, eight junior members had also won admission to the club.

Early Proceedings of the Club contain a wealth of geological research and for many years the 'Proceedings of the Cotteswold Naturalists' Field Club' was the second most prestigious journal for geological papers, only surpassed by the Geological Society of London. Authors included Prof. James Buckman, Dr. John Lycett, Rev. P.B. Brodie, Rev. W.S. Symonds, Robert Etheridge, Dr. T. Wright and Hugh Strickland to mention but a few. Unfortunately collections survive only in part and with their eventual demise came a broadening of interests to include archaeology, ethnology and folk life. In addition to the Proceedings occasional papers' and lists were produced mainly covering the flora and fauna of the region, however these are now out of print.
(Vaughan, R. 2004)

In 1995 the Club made the decision to reintroduce something of the ethic which led to its former strength, the excursions have a more practical interest, also the Proceedings contain more papers of a geological interest. The changes have proved popular, and the club is attracting more serious minded researchers. Recently the Club has published a booklet on the 'Geomorphology of the Cotswolds', and is looking to publish other such material in the future. In 2000 the Club initiated the Lindsall Richardson Memorial Lectures, named after the Clubs most famous member. Speakers so far have included Professor Mike Benton, speaking on mass extinction events, and Dr Murray Gray on geodiversity.
(Walrond, L, 2000)

The 'Devil's Chimney'; a pillar of freestone left behind by quarrymen after cutting a tramroad to transport stone from quarries on Leckhampton Hill

SECTION 2

GEODIVERSITY IN THE GLOUCESTERSHIRE COTSWOLDS

SECTION 2 GEODIVERSITY IN THE GLOUCESTERSHIRE COTSWOLDS

2.01 Introduction

The influence of geology in the Cotswolds is widespread but maybe not immediately noticeable away from the escarpment where quarrying was at its most intense. The extensive quarries and cliffs provide access to the full 14.5 million years of Earth's history during the Middle Jurassic, plus the uppermost part of the Early Jurassic. Beyond the escarpment the rolling hills and steep sided valleys extend the long and varied geological history into the Late Jurassic, and numerous quarries display this fascinating record of ancient environments. In total there are over 20 million years of geological time represented in the Cotswolds that can be seen, interpreted and understood at numerous locations throughout the area.

The outcrop of British Middle Jurassic carbonate rocks are at their most impressive and noticeable in the Gloucestershire Cotswolds, and have provided classic sections for their study since the earliest days of geology. Much of the early work on interpreting and defining the Jurassic period was carried out here, even the first discovery of a dinosaur came from the Cotswolds in 1824.

The different Groups, Formations, Members and units are distinguished from each other according to differences in the types of rock, the types of fossils found in the rocks and by erosional surfaces that mark breaks in deposition of the sediments. The ages of the rocks range between roughly 200-155 million years ago (Ma). The changes in the types of sediment that make up different rocks and the fossils contained within them provide a wealth of information as to the environments in which these sediments were deposited. Close examination can provide a very clear picture of what the geography of the area was like at the time.

At the base of the Jurassic, and making up the bulk of the lower slopes of the Cotswold Escarpment are the clays and silts of the Lias Group. These clays were deposited on the floor of a failed rift basin, a deep seaway which occasionally shallowed to allow the formation of intermittent limestones and sandstones. The rocks that form the capping to these sediments, the Inferior and Great Oolite Groups, are almost exclusively marine and were formed mainly in warm tropical seas, much like those around Bermuda today.

The Cotswold Escarpment at Crickley Hill

2.02 Geological History of the Cotswolds

The rocks of the Lias Group, underlying the Inferior Oolite, were deposited in warm tropical seas in an area that was actively subsiding. The site of their deposition lay over the axis of a graben where sedimentation rates were relatively high, leading to the preservation of an almost complete biostratigraphical succession. Over the period of deposition of these sediments the sea level rose and fell a number of times and it would seem that occasionally it withdrew completely leaving the sea bed exposed as dry land.

Clays and silts of the Lias Group with beds of limestone visible in the cliff

Initially finer sediment such as silty clay was deposited in the deeper areas, followed by successively coarser grades of sediment as water depth decreased. As sedimentation rates decreased up through the cycles the environment became more amenable to living things and was colonised by shelly animals and burrowing invertebrates. It is likely that many of the creatures were dissolved after being buried and were redistributed to form the calcareous bands found among the clay. At the top of each cycle the input of clastic sediments from the land virtually ceased, resulting in a population explosion among the fauna and the consequent formation of the beds of limestone.

The next part of the sequence consists of shallow water marine limestones belonging to the Inferior Oolite Group. The junction between the Lower and Middle Jurassic rocks marks a change from the rapidly subsiding Liassic basin into a relatively stable environment. These warm, shallow seas allowed life to flourish leaving abundant fossil remains, whilst large submarine dunes formed of ooids developed in the tidal currents. In the Middle Jurassic the sea shallowed considerably and silts and clays gave way to the formation of the typical Cotswold Limestones.

Changes in sea-level during the Middle Jurassic led to repeated shallowing of the sea and sea bed surfaces being planed off, producing unconformities. The sea bed then sank again to form a shallow sea in which gentle folds in the rocks allowed formation of lagoons, protected from the open sea by a reef barrier. Worms, snails, oysters and other types of

The contrast between the Lower Jurassic Lias Group (grey area to right of the tree) and the overlying Middle Jurassic Inferior Oolite rocks in Limekilns Quarry, Leckhampton Hill

shellfish colonised the area and contributed to the limestone formation as fossils. Oyster-encrusted and worm-bored surfaces mark a layer where the sediment had already turned to rock, hard enough for them to cling to. These surfaces, known as hardgrounds, mark a temporary break in sediment deposition, a period of erosion - or both. Some coastal areas re-emerged from the sea and were again planed down by erosion. Those areas that remained submerged developed sandy beds producing a great variety of rock types across the area.

Sand Mine Quarry, Cleeve Hill. The grey band in the centre of the picture represents a lagoon environment. Calcareous concretions have developed in the soft sands below

The latter part of the Middle Jurassic saw deposition of the Great Oolite rocks that form the escarpment of the southern Cotswolds and the wide tablelands of the mid and northern Cotswolds. The Great Oolite is an extremely varied group of rocks, with major changes in sedimentary facies and faunas across the area, both laterally and stratigraphically, making generalisation difficult. Only the uppermost members, the Forest Marble and Cornbrash, extend over the whole of the area without significant change. The facies changes in the underlying members are interpreted as representing relatively deep water and open sea to the south and a shallow shelf sea to the north, with sand banks, lagoons and emergent land influenced by numerous changes in sea level producing the complicated variety of rock types.

Rolling Cotswold Hills around Winchcombe

Awareness and understanding of the sedimentary deposits and landforms developed during the Quaternary Period, with its glacial and interglacial episodes, is highly significant to the geoscientist working in Great Britain. The most extensive deposits in the Cotswolds area include the river terrace complexes of the Severn, Upper Thames and the Warwickshire and Wiltshire Avons, most of which were laid down during glacial stages. Till and associated glacio-fluvial and meltwater lake deposits from the Anglian Glaciation are present between Gloucester and the Malvern Hills and in the Vale of Moreton.

Close-up of the gravels and bedding at Spratsgate Lane

Spratsgate Lane sand and gravel pit, extracting Quaternary gravels as aggregate

Sediments laid down during the latest glaciation and the following temperate climatic stage, occupy the largest areas. Major deposits include terraces along the main river systems, fan deposits in the Severn Vale, and head deposits in the dip-slope valleys of the Cotswold escarpment. The post glacial sediments include river alluvium, extensive tracts of estuarine alluvium and tidal flat along the Severn, very widespread and spectacular landslips along the Cotswold Scarp (possibly the largest in Britain), and local occurrences of tufa and peat in the Severn Vale.

The terrace deposits record episodes of shallow but progressive river incision and planation; meltwater and post-glacial precipitation has carved valleys on the Cotswolds which are now dry or occupied by smaller misfit streams; landslipped areas on the Cotswold Scarp have a characteristic set of topographic features and are highly responsive to environmental change such as that caused by increased rainfall or ground engineering projects.

The valley of the River Windrush, near Naunton. A misfit stream occupying a valley much larger than the present watercourse

The numerous glacial episodes in Britain have left their mark in a variety of deposits and features, but the Cotswolds escaped the direct effects of late Quaternary ice sheets and glaciers. Instead the Cotswolds spent much of the Quaternary period as a periglacial/tundra environment, with permafrost underlying a surface regularly affected by freeze-thaw action that produced many of the deposits and features remaining today. During the temperate interglacial periods the area was beyond the reach of sea level rises and instead rivers and streams have shaped the land, developing deeply incised valleys, extensive river terraces and channel infills.

'The Ice Age' was in fact composed of cold or glacial conditions alternating with interglacial climates as warm, or warmer, than today. During the Quaternary huge ice sheets have repeatedly advanced and retreated across large parts of Europe and the effect of these ice sheets has been dramatic; they have changed sea levels, produced extensive erosion, transportation and deposition of the resulting sediments and caused the crust itself to sink and rise. River systems have drastically changed their courses, cut valleys and forced animal and plant life to migrate or in some cases become extinct.

Erosion in Great Britain has been very extensive during the Quaternary, so that deposits are very fragmentary. In the lower lands of southern and eastern England, where the glaciers reached their maximum extent, landforms and sediments are better preserved, and it is in these areas that the oldest and most diverse record can be found. Gloucestershire, lying within this tract, has a great variety of Quaternary landforms and deposits, developed over a wide time range.

Dry, incised valley running down the dip slope away from the escarpment

The oldest Quaternary deposits in the area are the Plateau Deposits, or Northern Drift, and the major deposits of this age in the Cotswolds are found in the Vale of Moreton and the Evenlode Valley. Originally they would have been more widespread but have been eroded from most areas. A clay layer between boulder clay and limestone gravel has been interpreted as a possible remnant of Lake Harrison, a huge lake that filled much of the area between the northern part of the Cotswolds right up into Leicestershire, fed by meltwater from the ice sheets surrounding it. Despite this, the direct impact of glaciation in the Cotswolds is slight and there is little or no evidence for glacial processes over most of the region, even though it is likely that early glacial episodes covered the whole of the Cotswolds and the Upper Thames Valley.

A dry valley with interlocking spurs created by river meanders near Bibury

The deep incision by most Cotswolds watercourses in their limestone dominated uplands means that floodplains tend to be narrow, with alluvium confined to the steep sided valleys. This is however influenced by the underlying geology, and where watercourses cross softer clays and mudstones the floodplains widen, generally in their lower reaches. The numerous rivers and streams that drain the Cotswolds mainly flow towards the southeast, influenced by the regional dip of the strata, and many form tributaries of the Thames. Major exceptions to this include the Rivers Chelt, Frome and Cam which flow northwest to the River Severn, and the River Isbourne which flows due north through the Winchcombe embayment. Changes in drainage have left behind many characteristic landscape features such as dry valleys, misfit streams, incised meanders and wind gaps.

The numerous springs and watercourses of the Cotswolds running into waterlogged ground have, in places, led to the development of small isolated peat deposits. Many of these have become obscured by alluvium but still provide valuable information on the nature of climatic and environmental change. Pollen analysis shows a progressive change from tundra to woodland, to cleared woodland and finally to an open environment. Tufa is a common feature around the springs and streams of the Cotswolds and substantial deposits occur, some nearly 4m thick and covering an area of hundreds of square metres. Many of these deposits have been exploited for lime during the 20th century. Tufa is still forming around many springs and streams in the area such as at Chedworth, Midger Wood and Woodchester Park where pebbles, twigs and leaves have been coated with a hard calcareous skin and tufa dams are developing small waterfalls.

Tufa formation in Cotswold streams: Left - Midger Wood Below - Woodchester Park

Various forms of gravity induced slope movements have disrupted the strata and produced a range of superficial features and structures all over the Cotswolds. Landlslips, cambering, gulls, valley bulges and solifluction spreads are commonly found on the steep slopes of the escarpment and upland valleys. The majority of these slope movements probably occurred during the Pleistocene, resulting from freeze-thaw action, but these processes still continue today, although on a smaller scale, with recent episodes of landsliding being identified by lobes of slipped material covering medieval ridge and furrow field systems and 19th century enclosures.

The major geological economic resource in the Cotswolds is the stone itself, either as high quality building stone, rough walling stone or aggregate. There is a long history of quarrying and mining in the area dating right back to the Neolithic, and quarrying and mining of Jurassic freestones was widespread up until the 1st World War (Green, 1992).

Recently the use of natural freestone is mainly confined to the highest quality construction and repair work, and the Jurassic limestones still provide material for walling stone and pulverised and reconstituted facing blocks. Numerous former workings have now given way to a small number of large, highly mechanised quarries.

'Cotswold Slates' forming a stone roof on a Cotswold farm building

The distinctive character of typical Cotswolds villages is a result of using locally sourced building stones. The grey-yellow-brown oolitic, sandy and shelly limestones from both the Inferior and Great Oolite have been used for thousands of years, and quarrying activities have been proved from Roman times with dressed limestone used in the walls of and in villas such as those at Chedworth and Witcombe.

Adding to the distinctiveness of the Cotswold villages is the extensive use of limestone roofing 'slates' or 'tilestones'. The main source of these 'Cotswold Slates' was from quarries in the Eyford Member of the Fullers Earth Formation and from mines in Oxfordshire where Stonesfield Slates were extracted. Large blocks of rock were left out over winter to allow frost action to separate the laminations into the correct thickness for roofing material. The thinly bedded shelly limestones of the Forest Marble Formation were once extensively worked for flooring slabs and decorative mantelpieces, and also provided tilestones, though of a lesser quality than those from the Eyford Member. The dry stone walls of the Cotswolds were generally constructed of the nearest and most convenient material, often quarried out of ditches or small quarries adjacent to the walls themselves.

Nearly all of the Jurassic limestones have, at some time, been crushed and used as aggregate. The Cornbrash and Clypeus Grit Member were particularly favoured for road building, but have been replaced more recently by the White Limestone Formation. This is currently worked extensively at Daglingworth Quarry where some agricultural lime is also produced. Other quarries that predominantly work stone for other purposes also produce lesser amounts of aggregate as a by-product (Sumbler *et al*, 2000). Agricultural lime has been produced from the Jurassic limestones at various sites in the Cotswolds, and especially along the escarpment at sites such as Crickley Hill and Leckhampton Hill where the remnants of lime burning can still be seen.

The old limekilns on Leckhampton Hill during the early part of the 20th century.

Sand and gravel continue to be dug, mainly from the river terrace and fan gravel deposits deposited during the Pleistocene and Recent (Green, 1992). The main sand and gravel workings to the south of the area now form the Cotswold Water Park and the majority of pits are in the terrace deposits of tributaries of the River Thames, (Sumbler *et al*, 2000).

The digging of clay for brickmaking and other uses has also diminished in the area. Several sites used to work the local mudstones for brickmaking, including Wellacre Quarry at Blockley which is an excavation of considerable size. Other former sites of clay extraction exist at Stonehouse and on the outlier of Robinswood Hill, but the poor quality of the clay when fired and the relative abundance of natural building stone meant that historically there has been little demand for bricks in the area. Use of the clays for pottery has been proved dating back to Roman times, when it was used in the local 'Glevum ware'.

A distorted brick from Gloucester Brickworks. Poor quality clay caused expansion of gases during firing, leading to "blowing" of the bricks.

The Jurassic rocks are the third most important source of groundwater in the UK and provide water for much of the uplands of the Cotswolds (Green, 1992). The Inferior Oolite aquifer includes the limestones making up the majority of the Inferior Oolite Group, plus parts of Bridport Sand Formation (Lias Group) below and Chipping Norton Limestone (Great Oolite Group) above. The aquifer forms the main part of the Cotswold Escarpment and varies in thickness from 80m in the NW to around 15m in the east. The Great Oolite Aquifer comprises limestones lying above the Fullers Earth and is consistently 40-45m thick. The Cornbrash also forms an aquifer, although relatively insignificant, between mudstones of the Forest Marble and Kellaways Formations (Sumbler *et al*, 2000). The limestones of the Great Oolite dip south-eastwards and contain numerous fissures that concentrate the movement of groundwater, producing springs and streams on the dip-slope and in valley sides.

a. Biodiversity

The limestone geology of the Cotswolds provides Gloucestershire with some superb examples of grassland rich in wild flowers, where orchids and butterflies abound. Woodland along the escarpment typically consists of beech trees, well suited to the thin alkaline soils. Valleys contain mixed oak, ash and maple on the dip slope, with rich varieties of shrubs and woodland flowers. Evidence from pollen analysis has shown that the natural post-glacial environment of the Cotswolds would have been mixed woodland, but much of this has since been cleared to produce agricultural arable fields, scrub and grassland where grazing of sheep was once a dominant influence on the land.

Unimproved limestone grasslands, such as the commons, that have escaped modern agricultural changes are important for their flowering plants and provide a habitat for butterflies and other invertebrates, many of which are now rare in Britain. Other aspects of the Cotswold countryside, such as streams, rivers, parkland, walls and hedges also provide habitats for many other plants and animals. Geological industrial sites such as disused mines and caves offer homes for bats; quarries can provide habitats for cliff dwelling birds and scree piles can contain rare plants such as the Cotswold Pennycress and provide basking sites for reptiles including adders.
(Cotswolds AONB Management Plan, 2004)

b. History

A large part of the distinctiveness of the Cotswolds comes from its historic remains, including landscape features, buildings and industry. These historic remains date from the stone ages right up to the present day, and provide evidence of continuous settlement in the area for thousands of years. Features include Neolithic barrows, henges and stone circles, Iron Age Hill forts, Roman Villas and roads, medieval towns and villages, tithe barns, dry stone walls, historic parks and gardens and the form of modern settlements in the landscape. Some archaeological sites are classed as Scheduled Ancient Monuments (SAMs) and are of national importance as well as being highly prized locally. Classic geological sites, both for science and industry, also contribute greatly to the historical landscape.

c. Industrial Heritage

The Cotswolds during the Middle Ages were famous for wool production. Later, during the 18th Century, the availability of water power in the Stroud area encouraged development of linen mills, many of which are still in existence although now used for alternative purposes. The cloth and woollen industry fuelled the need for a canal system to link the River Severn with the Thames and the Cotswold Canals formed the first navigable inland waterway, connecting Gloucester with London and the Midlands.

Building stone is another important product from the Cotswolds. The typical Cotswold stone buildings, towns and villages are what the public perceive as being what best describes the Cotswolds for them (Cotswolds AONB, 2004). The use of local building stones in many historic buildings and features is a major factor in the character and distinctiveness of the historic Cotswolds, and the colour of the stone varies depending on where it was quarried. The various building stones are a direct result of the geodiversity of the region. As well as providing building stone, the numerous quarries in the Cotswolds also supplied stone for lime production right up until the mid 20th century.

More recently, tourism has become the major source of income and employment in the Cotswolds. The variety of attractions, picturesque towns and villages and the natural environment make the Cotswolds one of the most popular tourist areas in the country. It is hoped that publication of this document will help to promote geodiversity as an added attraction to the area.

Long Barrow on Shurdington Hill. High quality oolite forms the walls of the chambers with the local 'grits' used as ballast around the barrow

d. Communities and Settlement

Most settlement in the Cotswolds is long established, and has developed over centuries and even millennia. The capital town of the Cotswolds, Cirencester, originated during the Roman period, and places such as Stow-on-the-Wold even earlier. Medieval markets still flourish and much original character has been retained. Georgian and Regency influence is still apparent in much of the stonework, contributing greatly to the local distinctiveness of the area.

Gradual change over thousands of years are reflected in the Cotswolds communities, settlements and landscape and the distinctive local stone has played a major part in the development of the area. From prehistoric barrows, Roman villas and medieval manors, right up to modern buildings, the rich diversity of stone available in the Cotswolds has provided the raw materials for the development of communities and settlements in the area.

The oldest remnants of communities living in the Cotswolds come from the numerous long barrows such as Hetty Peglar's Tump and Belas Knapp, and the less common standing stones, such as the Rollright Stones, dating back to the Neolithic and Bronze Ages. The arrival of the Iron Age, around 500 BC is marked at places such as Crickley Hill where the postholes left by Bronze Age long-houses are overprinted by those of Iron Age round-houses. Farming and agriculture developed at this time, becoming the dominant way of life and driving the growth of established settlements.

By the time the Romans arrived in Britain, the area was extensively farmed and heavily populated. Many impressive villas were built in the Cotswolds, remains of which can be seen at Chedworth and Great Whitcombe. These used a great deal of local stone and natural materials, for both the structure and decoration of the buildings. Cirencester, known to the Romans as *Corinium*, was the largest Romano-British town outside of London, while Gloucester was the military centre for the region.

The remains of the Roman amphitheatre at Cirencester, with the town in the background

There are a number of different designations and levels of status for geodiversity sites, covering those of importance on international, national, regional and local scales. The majority of all sites are the result of human quarrying activities, be they ancient or modern. Most of these sites are no longer worked and provide an excellent opportunity to see what the Cotswolds are made of, quite literally. Working quarries are also a valuable asset to understanding the geodiversity of the Cotswolds as they are continually exposing new rock that undoubtedly still holds a few surprises for the geologist. Both naturally occurring changes and human influence can have negative impacts on geological conservation unless sites are positively managed for the geological interest.

A brief review of some of the designations used for geological and geomorphological sites is given below.

a. The Geological Conservation Review (GCR)

The GCR was designed to identify those sites of national and international importance needed to show all the key scientific elements of the Earth heritage of Britain. These sites display sediments, rocks, fossils, and features of the landscape that make a special contribution to our understanding and appreciation of Earth science and the geological history of Britain. There is now an inventory of over 3000 GCR sites, selected for around 100 categories (the GCR 'Blocks'), encompassing the range of geological and geomorphological features of Britain. The GCR sites form the basis of statutory geological and geomorphological site conservation in Britain.

<u>GCR Sites in the Gloucestershire Cotswolds</u>

In total there are 31 GCR sites within the Gloucestershire Cotswolds area, displaying a wide range of features in eleven of the GCR Blocks. The majority of these sites represent British Jurassic stratigraphy from the Toarcian to the Bathonian stages of the Early and Middle Jurassic, but also included are Jurassic-Cretaceous Reptillia, Mesozoic Palaeobotany, Palaeoentemology, Mesozoic-Tertiary Fish/Amphibia, the Quaternary of Midlands-Avon, Mass Movement and Fluvial Geomorphology of England.

b. Sites of Special Scientific Interest (SSSI)

SSSIs are the country's very best wildlife and geological sites, which include some of our most spectacular and beautiful habitats. Geological sites include active and disused quarries, river and coastal exposures, road, railway and canal cuttings and various different landforms of exceptional national importance.

The Earth Science Conservation Classification (ESCC) has been used since 1990 by English Nature and the other organisations to classify geological sites. The ESCC has numerous site types organised into three major categories: **exposure**, **finite** and **integrity**.

Exposure sites include active and disused quarries, pits and cuttings; coastal and river cliffs; foreshores; river and stream sections and mines and tunnels.

Finite sites contain geological features that are limited in extent so that removal of material may cause depletion of the resource. The features are often irreplaceable if destroyed. Site types include many mineral and some fossil deposits, mine dumps, finite underground mines and finite buried interest sites.

Integrity sites are geomorphological and are characterised by the need for holistic management. Site types include active and static geomorphological sites, caves and karst.

The importance of distinguishing between these three groups is that the successful management of each type usually requires a quite different approach. As a rule, exposure sites are more robust than integrity or finite sites and can often tolerate the effects of human activities to a greater degree.

<u>Geological / Geomorphological SSSIs in the Gloucestershire Cotswolds</u>

The designation of the thirty-one geological SSSIs in the Gloucestershire Cotswolds coincides with those sites recognised in the Geological Conservation Review (GCR). Features recognised and protected at these sites include stratigraphical sections and unconformities, important palaeontological sites, unique formations and structural features, active and fossil geomorphological sites and features that provide evidence of past environments and processes.

c. Regionally Important Geological / Geomorphological Sites (RIGS)

The statutory protection afforded to SSSIs protects sites of the utmost importance but many other sites that are important to local and regional geodiversity are excluded. This led to the introduction of the lower tier designation of RIGS for local and regional sites. The Malvern International Geoconservation Conference in 1993 stated the following reasons for site conservation:

RIGS have limited status in statute law but are widely used by local authorities in their planning decisions as a guide to land development, and there is a general "presumption against development" in much the same way as "Key Wildlife Sites". Cooperation with landowners greatly aids this process.

The whole process is managed by "RIGS groups" or their equivalent "Geology Trusts", or geoconservation organisations across the country. These are largely composed of experienced professional Earth scientists acting in a voluntary capacity. However, an increasing number of groups are now employing staff and building independent financial structures, as is the case in Gloucestershire.

RIGS in the Gloucestershire Cotswolds

In 2005 there were nearly 100 RIGS identified, surveyed and recorded throughout the Gloucestershire Cotswolds area, representing all aspects of geology and landscape in the area. The RIGS recording and validation group for the area is Gloucestershire Geoconservation Trust. The Trust holds and maintains a database of RIGS (and other sites) at the Gloucestershire Geological Records Centre (GGRC), on a specially designed database called "GeoSites".

d. Local Sites

In addition to those sites which have qualified as GCR, SSSI or RIGS, there are many other sites which still hold great interest in the study of the geology and landscape of the Gloucestershire Cotswolds. These are termed 'local sites' and recorded in exactly the same way as RIGS, except the data is not passed to the planning authorities, but kept in the database at the GGRC. All recorded sites are potentially valuable for further research in the area.

e. Lost Sites

A number of old sites that are mentioned in various literature and site records have since degraded to such an extent that the site itself is no longer visible. The historic records of these sites can still be valuable as references however and so records of these sites and their locations are also kept on the GGRC database.

f. Landscapes

Currently the majority of sites in the categories above are of geological rather than geomorphological interest, and cover relatively small areas defined by obvious boundaries. Wider landscapes and landscape features, including the escarpment edge, valleys and plains, are less well defined but are still important features in the geodiversity of the Gloucestershire Cotswolds. The need for more recoding of geomorphological and landscape features has already been identified as a priority action for the Gloucestershire Cotswolds.

g. Active Quarries

The importance of active quarries to geodiversity in the Gloucestershire Cotswolds cannot be over emphasised. Working faces have the potential to produce new specimens and features and are constantly exposing new sections of strata not previously seen or recorded. A good working relationship with quarry operators is essential to developing geodiversity to its fullest potential.

Guiting Quarry

h. Stone Buildings, Monuments and Other Stone Constructions

Some of the most easily recognised and well known features of geodiversity in the Gloucestershire Cotswolds are the vernacular stone buildings, monuments, dry stone walls, bridges and tunnels. Building stones, wherever they are used, are a very useful means of relating geodiversity to peoples' everyday lives but the sources of these stones are often overlooked in local interpretation provision. The heritage provided by Cotswold dry stone walls and roofing slates is famous all over the world and stone from the area is still a highly prized commodity.

Stone Bridge over the River Windrush at Naunton

i. Earth Science Interest on Sites Designated for Other Purposes

There is rarely such a thing as a ‘single interest site. Management and conservation of all sites therefore needs to take into consideration all of the features of interest and to resolve any conflicts of conservation interests that arise. The Gloucestershire Cotswolds is entirely within the Cotswolds AONB, and includes many sites designated for their biological and wildlife importance. However, many of these sites also have value to geodiversity, and nine of the SSSI in the area have combined geological and biological designations. Such sites provide excellent opportunities to develop an integrated approach to nature conservation, and demonstrate the close association of bio- and geo-diversity.

Four Mile Lodge Quarry near Cirencester.
Faces are becoming overgrown and exposure lost

The long and varied history of human settlement and industry in the Cotswolds is also related to the area’s geodiversity. The whole length of the escarpment has been quarried and many of these old quarries now provide some of the best geological exposures. Building stones have been widely used from Roman times to the present day, for villas, tithe barns and Regency Cheltenham, as well as the characteristic Cotswold Stone villages and towns. Other sites such as Leckhampton and Crickley Hills have the remains of old limekilns. Even the oldest archaeology in the area, the Cotswold-Severn Long Barrow Group, shows a deep practical understanding of the local geology in their construction.

j. Opportunities to Enhance Geodiversity Features.

Excellent opportunities to enhance geodiversity are often created by major engineering projects, such as road building or widening, railway cuttings and canal works. Even temporary trenches dug during groundworks provide an insight into previously unseen geodiversity features. Such opportunities should be viewed positively as contributing to the available geodiversity and, whenever possible and practicable, left available for further study and interpretation.

Shakespear Quarry near Ozleworth.
Fly-tipping here has impeded access to much of the site

There are currently two working railway lines passing through the Gloucestershire Cotswolds that are not available for study. However, disused railway lines between Andoversford-Bourton-on-the-Water and Andoversford–Kemble provide cuttings in which some of the areas most important geology can be seen. Many of the classic sections of Cotswolds geology have been recorded from these cuttings, and they provide potentially excellent sites for school parties and students as well as geologists.

The Cotswold Canals Partnership aims to restore navigation of the two 18th century canals in the Cotswolds, the Stroudwater Navigation and the Thames – Severn Canals. The restoration of these canals could provide access to previously unavailable geodiversity features, in cuttings, tunnels and bank-sides, and allow appreciation of the diverse landscapes of the Cotswolds from a different viewpoint. The local geodiversity is also reflected in canal architecture, with bridges and locks at the eastern end made from locally sourced material.

(John Conway, Royal Agricultural College, Cirencester)

The following is extracted from English Nature's Natural area profile No. 55

"The Cotswolds occupy a well known part of the band of Jurassic limestone country stretching from Somerset to Warwickshire where the underlying geology is the major influence determining the landscape and landform, while the associated soils support the characteristic plant and animal communities of the Natural Area.
For example, shallow well drained brashy soils of the dip slope around Cirencester and into Oxford support cereals and stock farming, while heavier soils around Bath and Moreton support dairying. More than 80% of the Cotswolds is farmed, making agriculture the most significant influence on biodiversity."

The Cotswold area is easily recognised from the Soil Survey of England and Wales National Soil Map [sheet 5 SW England]. Soils are mapped as "associations" – convenient mapping units defined usually by geology, topography or a combination of both. The Cotswold Hills correspond closely to the outcrop of Jurassic limestone; Cotswold 'landscape' extends to relatively narrow surrounding areas of underlying or overlying clay [Lias / Oxford respectively] or superficial glacial or outwash deposits.

a. Definition of Soils

Soils are formed due to the interaction of environmental factors [climate & biota] acting on parent material within a topography over a period of time. For the Cotswolds, this means a postglacial sequence of climate change and ecosystem development resulting in the current temperate climate with natural grassland and mixed deciduous woodland occupying an area of soft limestone interbedded with thin clay shales forming a gentle escarpment following the geological dip, i.e. gently to the south east. The limestone weathers slowly by solution to leave a thin residue of non-carbonate material [silt and clay] and residual carbonate sand, grit and stones. The resulting soil is classified as a brown rendzina [code 343] of the Sherborne Series or a brown calcareous soil [code 511] of the Moreton Series

Sherborne Series

- ***typically around 25cm of very stony reddish brown, friable, clay topsoil directly over limestone.***
- ***high pH, typically 7.5 – 8.0***
- ***well drained and easily cultivated over long periods***
- ***droughty in the absence of rainfall***

An example of a section through Sherborne Series soil.

Moreton Series

- ***typically around 25cm of very stony reddish brown, friable, clay topsoil over a yellowish brown clay subsoil over limestone at c. 50cm.***
- ***high pH, typically 7.5 – 8.0***
- ***well drained and easily cultivated over long periods***
- ***moderately droughty in the absence of rainfall***

An example of a section through Moreton Series soil.

The presence of interbedded clay shales leads to greater diversity. Soils of typical calcareous pelosols [code 411] of the Evesham series occur on clay, with intergrade soils of the Haselor series where limestone is present at moderate depths [c 50cm]. These two are greyish brown, stone free topsoils of clay texture with poorly drained subsoils and little or no drought problem.

b. Diversity of soils in the Gloucestershire Cotswolds

The predominance of the Jurassic limestone leads to a dominance of the shallow "brashy" soils of the Sherborne and Moreton series, depending on the arbitrary depth classification [30cm]; typically 70 -80% of the area.

The presence of the clay shales at shallow depth may lead to situations where the limestone soils are poorly drained, and at the surface leads to wet clay soils.

In agriculture, this tends to explain the pattern of arable and permanent pasture, in biodiversity terms, the pattern of grassland / beech woodland with oak woodland [in a very simple generalisation].

Dry valley floors are characterised by deeper versions of the limestone soils; river valleys are rare but characterised by pelocalcareous alluvial gleys soils [code 814] of the Thames series (above) with high water tables.

The rarer soils of the Cotswolds are those where either the limestone is less pure, or contains more sand and weathering / leaching has left an acid sandy / silty textured soil most noticeable at Westonbirt Arboretum

c. Influence on the landscape and social and industrial history

Agriculture is largely defined by the opportunities offered by the soil – in this area shallow stony, droughty soils led originally to sheep grazed grassland and crops of barley. In turn this supported the wool industry and shaped much of the economic development of the area. In more modern times, agricultural developments in terms of crop breeding, machinery and agrochemicals has led to greater diversity of enterprises. However changes in EU policy and funding are beginning to reverse this agricultural trend.

d. Influence on biodiversity

Soil conditions influence the ecosystem development – for the most part these soils support calcicole ecosystems, though the restricted occurrence of the Evesham and related wetter soils support a less drought tolerant woodland ecosystem. The occasional neutral to acid soils allow a more diverse flora and are well exploited at Westonbirt Arboretum for example, and by some farmers for other crops [eg potatoes].

e. Future requirements

Changes in agricultural policy and funding mechanisms may be expected to lead to fewer dairy farms and less intensive arable farming, though increased grassland for recreational horse enterprises may be envisaged. Conservation should be considered for the rarer acid soils which offer an alternative habitat to the mainstream limestone soils.

SECTION 3

GEODIVERSITY AUDIT

SECTION 3 GEODIVERSITY AUDIT

3.00 Aims and Objectives of the Geodiversity Audit

The following section contains a geodiversity audit of the Cotswolds. The audit is a survey of all the geological and Geomorphological resources within the study area. The main aim of the audit is to review the geological components and landforms present within the Cotswolds, and to assess their relevance and importance in a local, regional and national context. It will provide a geological framework to assist in the sustainable management, planning, conservation, interpretation and education relating to all aspects of Earth Heritage within the Cotswolds, both now and for the future.

The audit shows the representation of the stratigraphy and geological features present within the study area and highlights the wide geodiversity or geoheritage and potential geodiversity of the Cotswolds. The audit is not intended as a detailed geological description of the Cotswolds, but an overview of the rock succession and landforms, and forms an essential background to the LGAP. The brief lithological descriptions for each rock unit are modified after the British Geological Survey (BGS) Lexicon of Named Rock Units.

The audit has indicated those groups, formations, members and individual rock units that are poorly, moderately or well represented, based on records held by GGT from exposures at all recorded geological SSSI, GCR and RIGS sites. These may be active or disused quarries, road or railway cuttings or natural outcrops. Also included in the audit is an assessment of the current condition of the exposures at each site; the SSSI conditions are English Nature's own site assessments. The RIGS assessments are based on a similar criteria to that used by English Nature, based on Common Standards (Joint Nature Conservation Committee 1998), being either in favourable or unfavourable condition, maintained, stable, declining, partially destroyed or destroyed (lost site).

An extensive literature search and desktop study has indicated that there are many other sites not specified in this audit, exposing various formations and members. These sites have been identified by GGT, but have yet to be surveyed and therefore have no designated status. These sites will be included in future site surveying work that the Trust will carry out.

Each Group, Formation or Member is also referenced to the Cotswold AONB Landscape Character Assessment, proving the link between the underlying geology and specific landscape character types.

3.01 The Geological Framework

a. Regional Structural Setting

The LGAP study area essentially covers the north and mid Cotswolds, which structurally is situated to the southern end of the Worcester Graben, a north-south trending Palaeozoic extensional basin. It is defined and bound to the west by the Malvern Axis, to the east by the Vale of Moreton Axis and the westernmost part of the London Platform, and to the south by the Wessex basin.

During the Jurassic period, the Worcester Graben was the site of a narrow tidal seaway, linking the Wessex Basin to the south with the East Midlands Shelf to the north and the London Platform to the east. Subsidence within the Worcester Basin began during Permian times, and a thick accumulation of Triassic and Lower Jurassic Lias Group sediments had effectively infilled the basin by the end of the Early Jurassic. The succeeding Inferior Oolite Group rests erosively on the underlying beds.

The basin developed as an extensional graben during Permo-Triassic rifting, linked partly to the early stages of the opening of the Central Proto-Atlantic ocean during the Mesozoic (Duff & Smith 1992, Loup & Wildi 1994). Ultimately this resulted in two episodes of east–west crustal extension and subsidence during the Permo-Triassic. This was controlled by the reactivation and inversion of Variscan reverse faults as a series of major north–south trending basin margin normal faults (Barclay *et al* 1997).

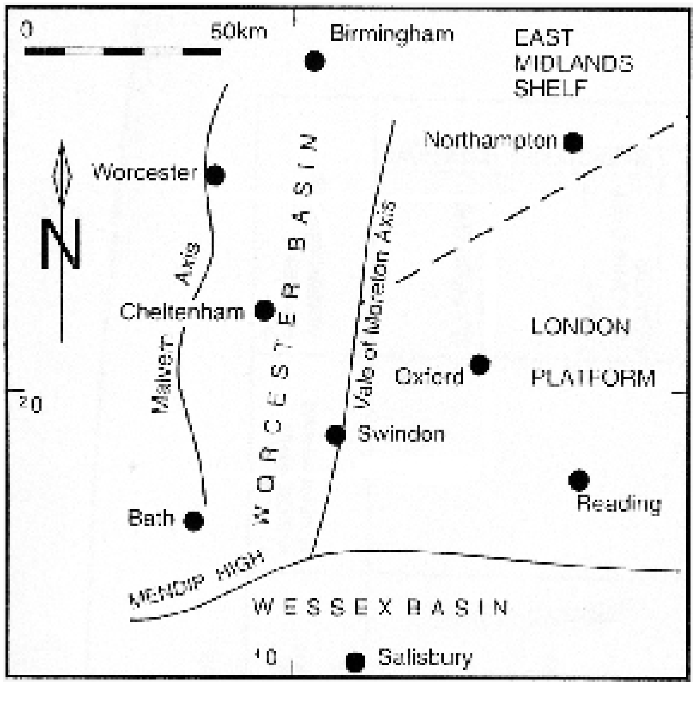


Fig. 3.1
Regional setting of the Cotswolds, showing the principal Mesozoic structural elements (Barron et al, 1997)

This faulting led to the collapse of the previously uplifted horsts, and the formation of the basin through two extensional episodes (Chadwick 1985). The first during the early Permian, through rapid, fault-controlled subsidence, accompanied by active stretching, followed by more gradual subsidence. The second episode occurred during the early Triassic, and followed a similar trend of rapid subsidence followed by more gradual subsidence after the extension had ceased. This contiued into the Early Jurassic. These tectonic processes led to the development of a large system of independently subsiding fault-bound blocks, forming basins with rapid deposition and swells with little or no deposition (Hallem & Sellwood 1976). These blocks controlled sedimentation patterns locally. The basin succession shows considerable thickness variations, with deposition greater to the west, along the Malvern Axis and with eastward lateral thinning onto the Vale of Moreton Axis. This is attributed to differential subsidence rates and major normal faulting at the basin margins and along smaller faults within the basin itself. (Barclay *et al* 1997).

In addition to the major north-south trending structures, the Middle Jurassic succession in the central and north Cotswolds indicates a localised structural influence through a series of minor northwest – southeast trending basement faults. Episodes of periodic subsidence followed by longer periods of stability and erosion are believed to have occurred along these faults and are identified by contemporaneous erosion (Simms 1990).

Throughout the Jurassic Period, the London Platform remained a relatively stable persistent high. The contact between the platform and the Worcester graben is defined by the reactivated Moreton Axis fault, as indicated by seismic data (Barron *et a*l 1997). During the Mid Jurassic, this basin formed part of the Cotswold-Weald Shelf, a shallow ramp dipping gently in a south westerly direction away from the London Platform towards the Wessex Basin (Mudge 1995).

Deposition in the North and Central Cotswolds was limited to, and controlled by, the Malvern and Vale of Moreton axes. These are two major normal faults, forming the fault-bound basin and marking the shorelines during part of the Middle Jurassic. These axes, as described by Buckman (1901), are a set of north-south trending Palaeozoic structures, defining the Worcester Basin's boundaries. Within the basin are a series of minor structural features, with similar north-south trends; these are from west to east, the Painswick Syncline, the Birdlip Anticline, the Cleeve Hill Syncline and the Moreton Anticline. Buckman suggested that earth movements along these axes were responsible for the two major breaks in sedimentation, the Aalenian and Bajocian denundations, and that the underlying strata had been folded to create a series of "anticlines and complementary synclines." These structures had the effect of dividing the basin into a series of sub-basins, with sedimentation and sequences thicker and more complete in the synclines, thinning along the limbs in an eastward trend and truncating at the anticline axes. More recent work has indicated that the Moreton axis acted as a hinge to the east of the Worcester Basin, with greater, more rapid subsidence in the west, with sedimentation thinning eastwards.

On a local scale, the structure of the Jurassic rock succession as seen at outcrop within the Cotswolds is relatively simple; the strata is seen dipping predominantly in a south to south-easterly direction at shallow angles of between 0.5° to 1.5°. Locally at outcrop, higher or anomalous dip directions and values can be seen, these are generally the result of minor folding associated with faulting, or by the superficial effects of cambering or valley bulging (Sumbler, Barron & Morigi 2000).

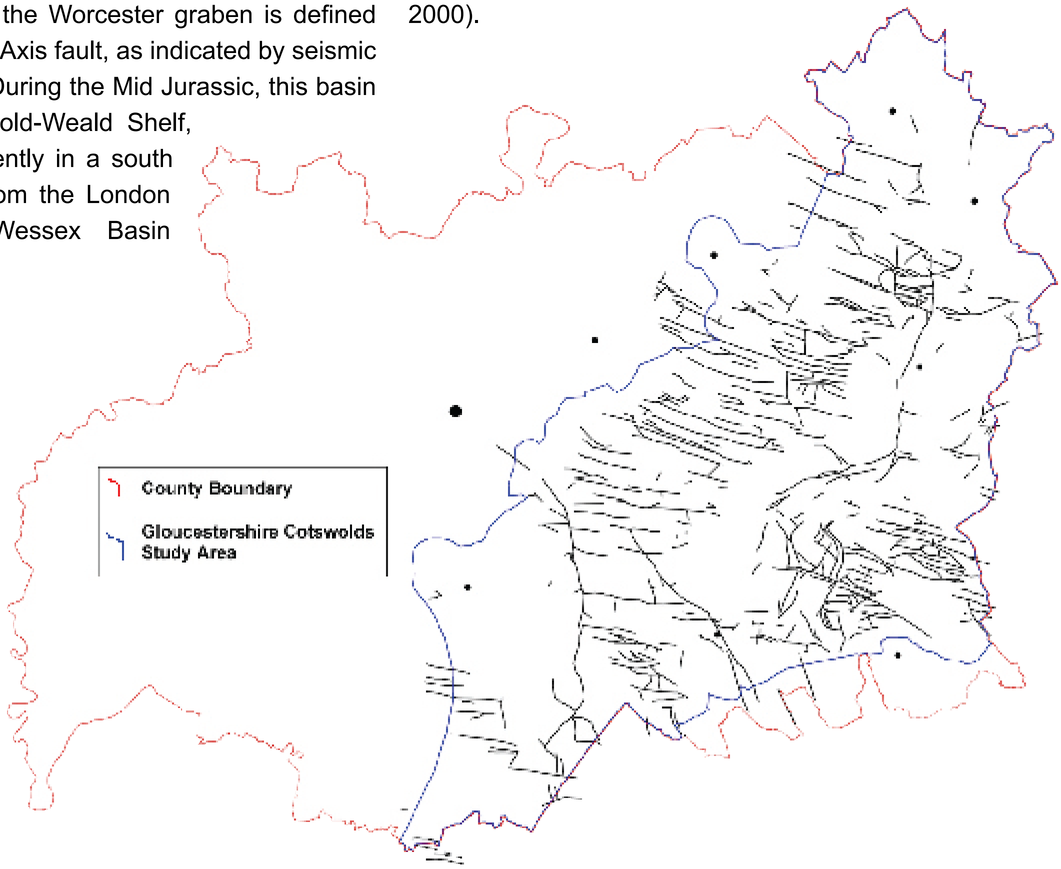


Fig. 3.2 Faults in the Gloucestershire Cotswolds

b. Faults and Folds

At the surface, two predominant fault trends can be recognised, north-south and east-south-east. Throw on these faults is generally within the order of a few metres but some have larger displacements of between 20m to 40m and can be traced running in excess of 10km. In addition to these structures, graben structures also occur, on both a large and a small scale.

The predominant fault trend in the Cotswolds is from west-north-west to east-south-east and this trend is particularly common around the Cirencester area. It is uncertain as to the effects these faults have at depth and on deposition patterns. Their trend suggests an association with the Late Jurassic-Early Cretaceous phase of crustal extension, associated with the continued development of the Wessex Basin. There is some indication that these fault trends may have influenced sedimentation during the Lower Jurassic (Simms, 1990), and certainly had an effect on local thickness variations within the Inferior Oolite Group during the Mid Jurassic.

While the north-south trending faults are less common, they are more significant in terms of deep structure. They form a predominantly north-north-east to south-south-west trending fault belt (associated with a number of sub-parallel faults), that include the Clapton, Bibury and Ready Token faults. Seismic data indicates that they are surface expressions of the bounding fault to the eastern margin of the Worcester Basin. This belt therefore marks the Vale of Moreton Axis (anticline), characterised by a marked thinning and truncation of the lower Inferior Oolite Group sediments passing eastwards towards and over the Moreton Axis.

c. Sedimentological Effects of Structure

The underlying structure of the region has therefore had a major effect on sedimentation patterns within the Cotswolds. Buckman published his classic theory in 1901, stating that the various structural features affecting the strata of the Lower and Middle Jurassic of the Cotswolds were active during deposition of the Inferior Oolite Group. Earth movements along the series of N-S trending fold axis were responsible for two major breaks in sedimentation during this time, the Aalenian and Bajocian transgressions. These structures are the Vale of Moreton Anticline, the Cleeve Hill Syncline, the Birdlip Anticline and the Painswick Syncline. More recently, Mudge (1978) has demonstrated these features did indeed influence the rate, distribution and thickness of Inferior Oolite Group sediments, and that facies belts within the Cotswolds also followed this N-S trend. The Vale of Moreton anticline is characterised by a marked thinning and truncation of sediments passing eastwards towards and over the anticline, a topographic 'high'. In comparison, the Cleeve Hill Syncline, a topographic 'low' or trough, is characterised by a thickening of sediments, with deposition occurring in a basin allowing the maximum thickness of sediment to build-up.

d. Superficial Structure

In addition to the major underlying structure of the Cotswolds, within the region there are also a number of shallow or surface features. These are predominantly gravity-controlled mass movement and superficial structures, including landslips, cambering and valley bulging. These superficial structures are covered in section 3.05.

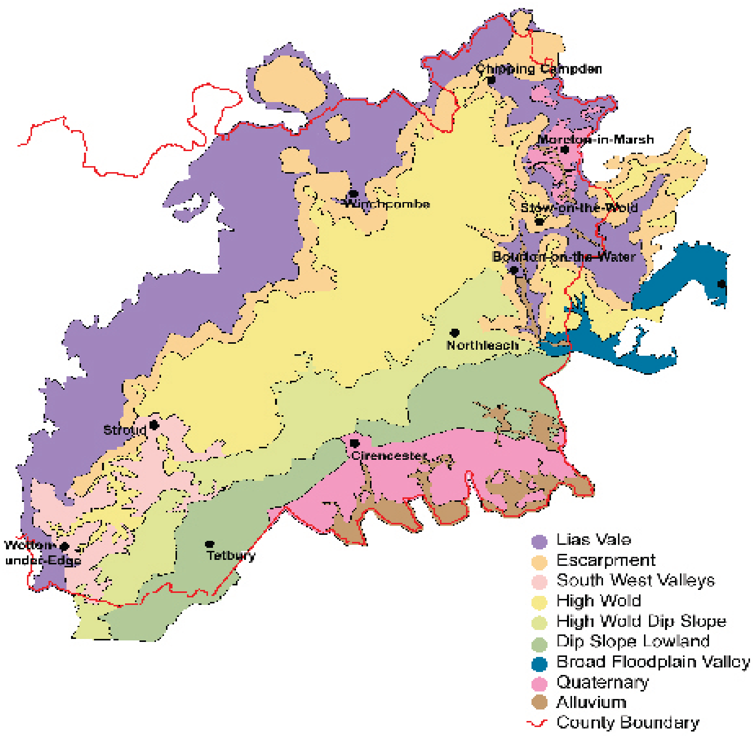


Fig. 3.3
Gloucestershire Cotswolds Landscape Character

(based on the Cotswolds AONB Landscape Character Assessment, 2004)

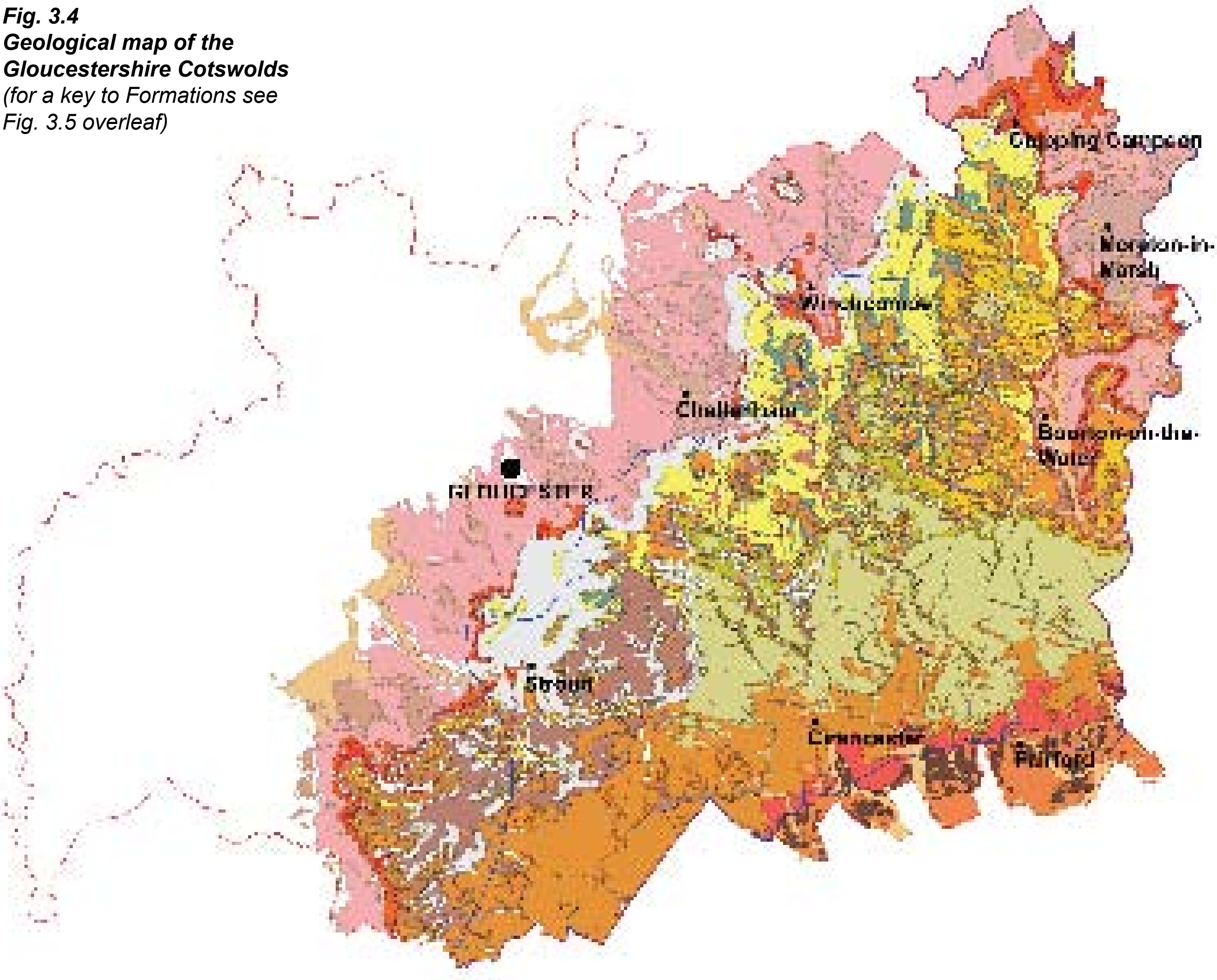
3.02 The Palaeozoic Basement

Underlying the Jurassic sequence of the Cotswolds are the older Palaeozoic and early Mesozoic basement rocks. These are a sequence of rocks dating from the Precambrian through to the Triassic period. None of this sequence is exposed within the Cotswolds but is inferred from borehole data and interpretation of seismic reflection data from within the Cotswolds and adjacent areas, at depths of over 2km.

3.03. The Stratigraphical Succession in the Gloucestershire Cotswolds

The exposed Cotswold stratigraphical succession is Jurassic in age and predominantly marine. The strata ranges from mudstones, siltstones and clays of the Lias Group, through to the predominantly limestone sequences of the Inferior Oolite and Great Oolite Groups, passing into mudstones, sandstones and clays of the Ancholme Group (Kellaways and Oxford Clay Formations). The Jurassic succession is capped in places by broad tracts of unconsolidated, superficial Quaternary deposits, collectively known as “drift”. These deposits consist predominantly of fluvial sands and gravels, laid down during the Pleistocene Ice Ages.

Fig. 3.4
Geological map of the Gloucestershire Cotswolds
(for a key to Formations see Fig. 3.5 overleaf)



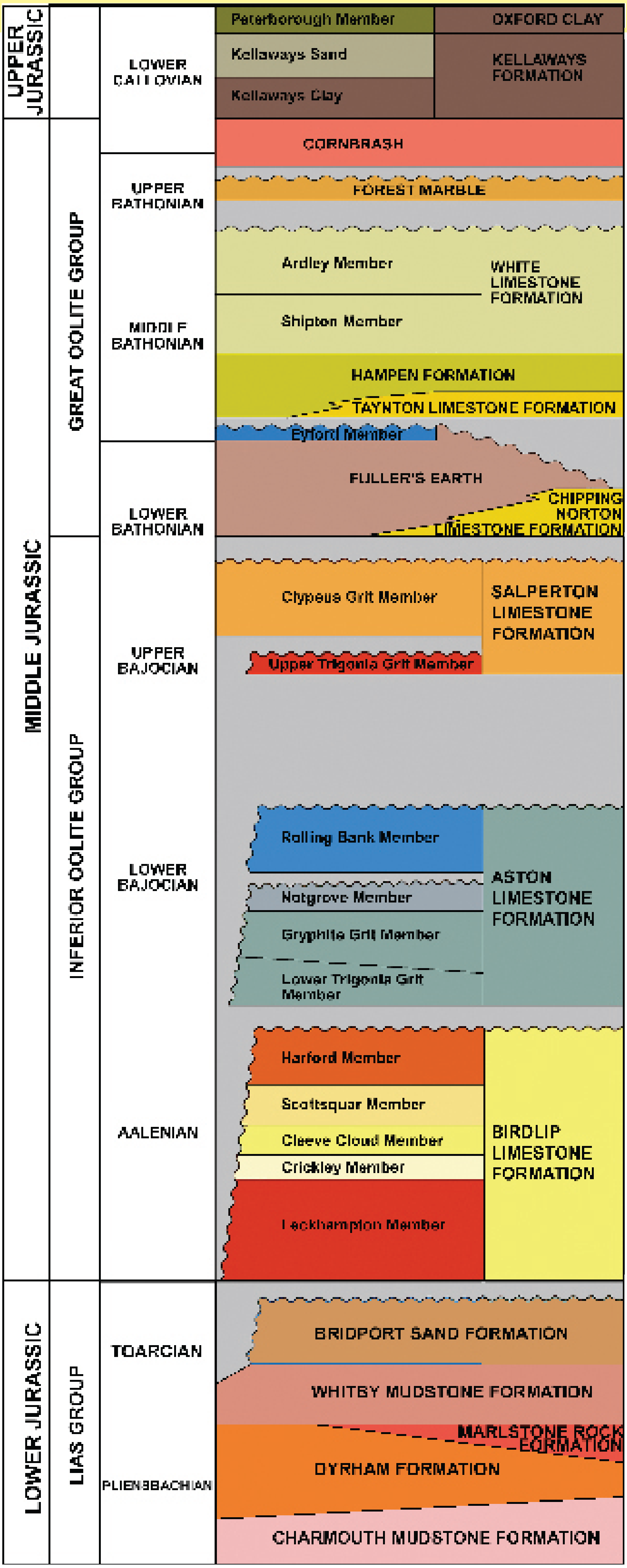


Fig.3.5
The full stratigraphic sequence of formations and members in the Gloucestershire Cotswolds.
(Partly based on Barron *et al*, 2000)

a. Lower Jurassic - Lias Group

Rocks of the Lias Group are the oldest outcropping in the region, with generally only the upper part seen at the surface. The Lias Group underlies most of the region, and five of the six formations within the group are exposed at twenty-five different sites. Exposures are generally limited to the lower slopes of the escarpment and outcrops along valley floors, essentially the Lias Vale Landscape Character, based on Cotswold AONB Landscape Character Assessment (Cotswolds AONB, 2004). The sites exposing the Lias are therefore generally confined to the area west of the Cotswold escarpment and to the northeast of the region along the Vale of Moreton. Due to the topography of the study area, exposures of the Lias Group within the lower (older) formations are, as expected, generally poorly represented, with the oldest and stratigraphically lowest, the Blue Lias Formation not exposed at all. The older formations within the group are exposed at thirteen sites, with the exception of the uppermost formation, the Bridport Sand Formation, exposed at fourteen sites. In addition to the relatively limited number of sites within the Lias group, their condition can generally be considered as unfavourable and declining. This is in part due to the soft nature of the sediments, the growth of vegetation, often obscuring the exposures and that limited, or no geoconservation work has yet been undertaken at these sites.

Thickness: Up to c.1300m

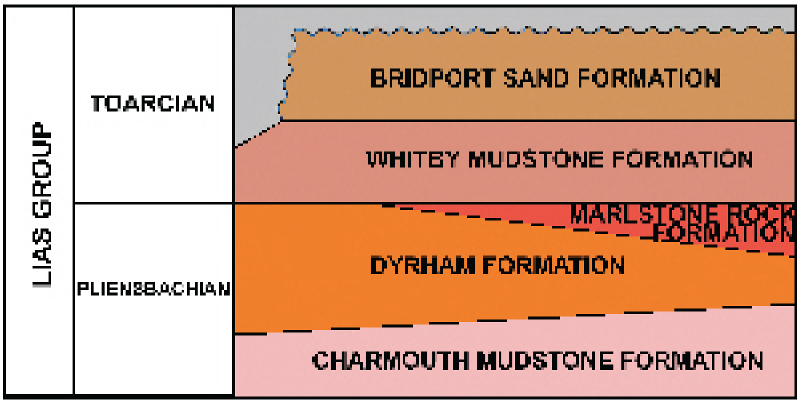


Fig. 3.6 Stratigraphy of the Lias Group (Lower Jurassic)

a.i Charmouth Mudstone Formation

The oldest and stratigraphically lowest formation of the Lias Group exposed within the study area is the Charmouth Mudstone Formation (formerly the Lower Lias). Exposures are currently limited to only five sites and most of these consist of relatively poor exposures considered to be in unfavourable condition and declining. The best of the sites, Wellacre Quarry (Blockley Brickworks) is a geological SSSI, GCR and the BGS reference section for this formation. This site contains the best inland exposure in Britain of the Charmouth Mudstone and Dryham Formations (Lower and Middle Lias). The strata here contain an abundant fossil fauna, including a very important suite of ammonites.

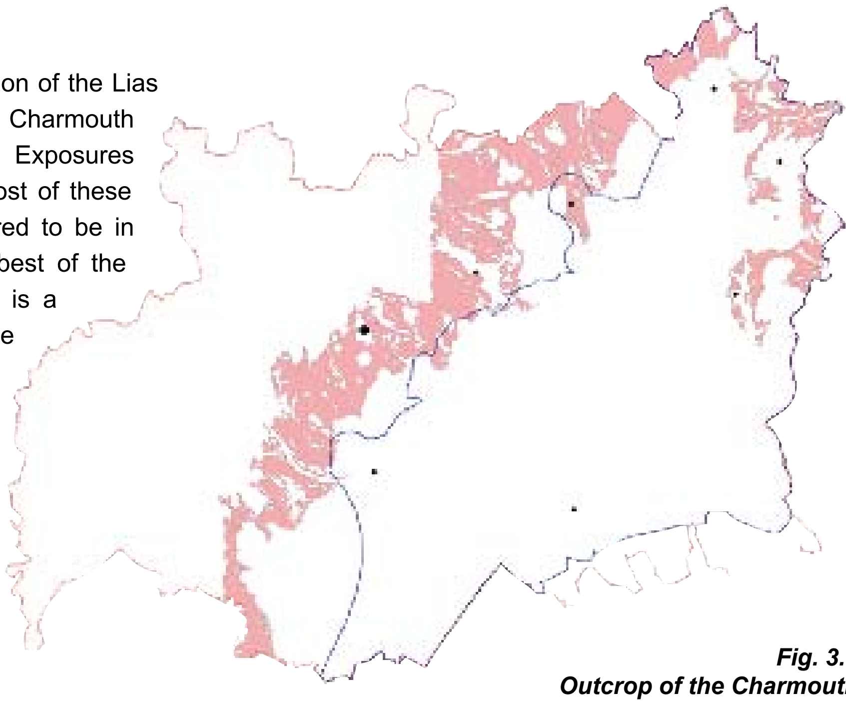


Fig. 3.7 Outcrop of the Charmouth Mudstone Formation

Primary Reference Section:
BGS Stowell park Borehole
(Reg. No. SP 01 SE/1) (SP 0835 1176)

Reference Sections:
Wellacre Quarry, Blockley Brickworks, Blockley
(SSSI, GCR) (SP 182 369)

Lithology:
Mudstones with thin beds of limestones. Dark grey laminated shales, dark grey to pale grey and bluish grey mudstones; occasional concretionary and tabular beds of argillaceous limestone. Upper boundary defined by marked or gradational upward change to coarser siliciclastic deposits of the Dryham Formation.

Thickness: Variable, 130-290m in North Cotswolds, 50m+ in Cirencester district.

a.ii Dryham Formation

Above the Charmouth Mudstone Formation is the Dryham Formation (formerly part of the Middle Lias). Again, sites within this formation are poorly represented, limited to just five. The condition of these sites is generally unfavourable and declining. The most valued of these sites is Stonehouse Brick and Tile Co. & Jeffries pits, exposing over twenty metres of clays and sandstone, including at the base of the formation, the Capricornus Sandstone (Palmer, 1971). The Stonehouse site is a RIGS and BGS reference section for the Dryham Formation and the over-lying Marlstone Rock Formation. The condition of this site is likely to be unfavourable and declining. Surveyed by GGT in 1994, it was stated that the site would become over-grown and lost if no remedial work was carried out.

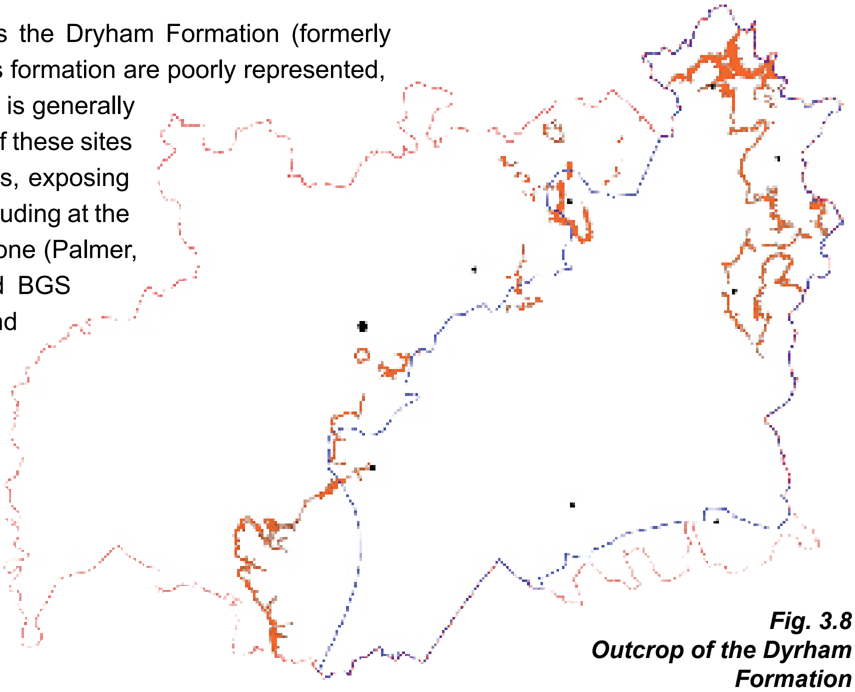


Fig. 3.8
Outcrop of the Dyrham Formation

Type Section:

Tuffley Brickworks, Robin's Wood Hill
(SSSI, GCR) (not within the study area)

Reference Sections:

Stonehouse Brick and Tile Co. & Jeffries Pits, Stonehouse - (RIGS) (SO 810,054)
BGS Stowell Park Borehole (Reg. No. SP 01 SE/1) (SP 0835 1176)

Lithology:

Silty mudstone and siltstone. Pale to dark grey and greenish grey, silty and sandy mudstone, with interbeds of silt or very fine sand, weathering brown or yellow. Variably micaceous. Impersistant beds or doggers of ferrunginous limestone (some ooidal) and sandstone which may be very fine or laminated. The upper boundary is defined by base of ferruginous limestone or ironstone of Marlstone Rock Formation.

Thickness: Variable, 15-61m in North Cotswolds, 15-54m in Cirencester district.

a.iii Marlstone Rock Formation

The Marlstone Rock Formation (formerly the upper part of the Middle Lias), is relatively rare in this region and again is poorly represented, limited to just five sites. As with the Dryham Formation, the best of these sites is Stonehouse Brick and Tile Co. & Jeffries pits (BGS reference section). The Marlstone Rock Formation forms the characteristic ledge below the Cotswold scarp and caps the steeply sloping under-lying Dryham Formation, which is associated with cambering and valley bulging.

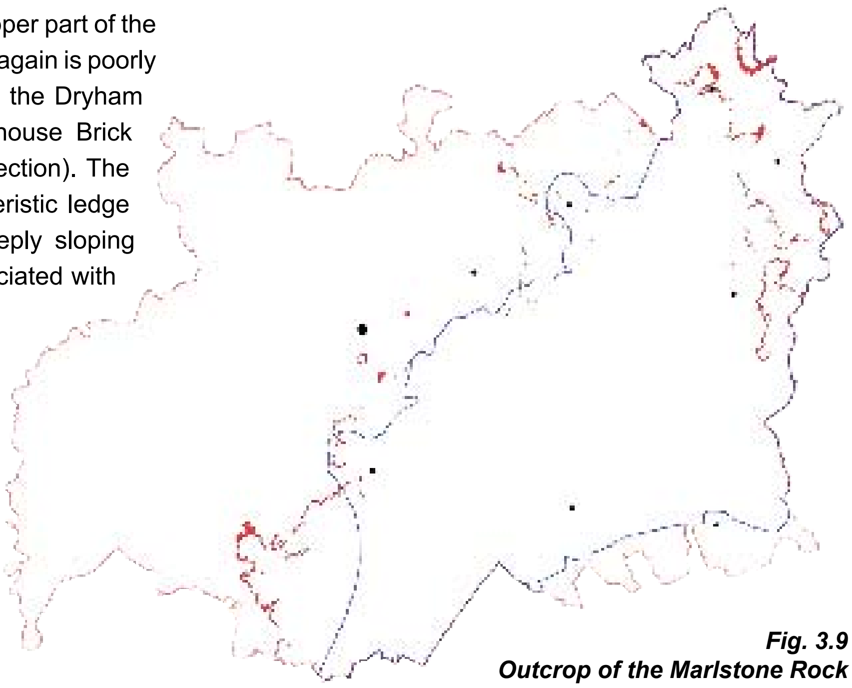


Fig. 3.9
Outcrop of the Marlstone Rock Formation

Reference Sections:

Stonehouse Brick and Tile Co. & Jeffries pits, Stonehouse - (RIGS) (SO 810,054)
North Woodchester Rail Cutting - (RIGS) (SO 8417 0303)
Old Quarries Gretton - (RIGS) (SP 012 295)
BGS Stowell Park Borehole (Reg. No. SP 01 SE/1) (SP 0835 1176)

Lithology:

Ferruginous, ooidal limestone and sandstone. Sandy, shell-fragmental, ferruginous ooidal limestone, weathering to limonitic ironstone, with ferruginous and calcareous sandstone; thin ferruginous mudstone partings; variably shelly but generally highly fossiliferous. The upper boundary is defined by an upward change to mudstone/nodular limestone of Whitby Mudstone Formation.

Thickness: Variable, 0-6m.

a.iv Whitby Mudstone Formation

The Whitby Mudstone Formation (formerly the Upper Lias), is also poorly represented, exposed at just six sites. These are mostly considered to be in unfavourable condition and declining, with the exception of Lower Limekiln Quarry, Leckhampton Hill (although this is a limited exposure of the Whitby Mudstone). Alderton Hill Quarry is a key palaeontological site and has long been famous for its well-preserved Lower Jurassic insect fauna, recovered from the "Fish Bed." This formation is commonly associated with landslips.

Primary Reference Section:

BGS Stowell Park Borehole (Reg. No. SP 01 SE/1) (SP 0835 1176)

Lithology:

Mudstone with limestone beds at base. Medium and dark grey fossiliferous mudstone and siltstone, laminated and bituminous in part, with thin siltstone or silty mudstone beds and rare fine-grained calcareous sandstone beds; dense, smooth argillaceous limestone nodules are very common at some horizons; phosphatic nodules at some levels. Nodular and fossiliferous limestones occur at the base in some areas. The upper boundary is defined, in northern areas, by a sharp, eroded boundary with limestones or sandstones of the Inferior Oolite Group; in the south Cotswolds, by a transition to sandy sediments of the Bridport Sand Formation.

Thickness: Variable, 25-111m in North Cotswolds, 12-98m in Cirencester district.

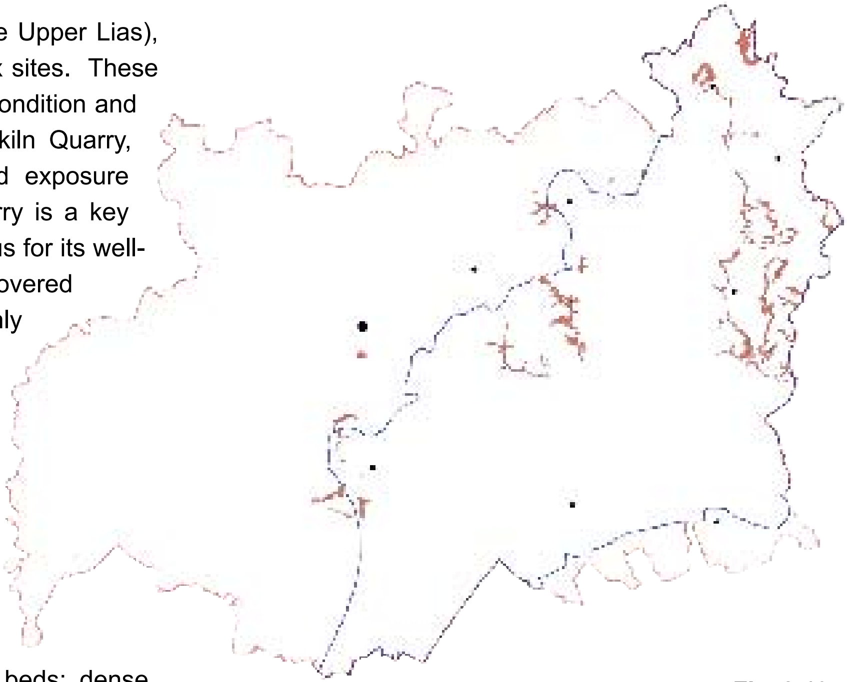


Fig. 3.10
Outcrop of the Whitby Mudstone Formation

a.v Bridport Sand Formation

The uppermost formation of the Lias group is the Bridport Sand Formation (formerly the Cotteswold Sands). This is moderately to well represented, exposed at fourteen sites, including six geological SSSI and GCR sites. The condition of most of these sites is generally considered to be unfavourable and declining, with the exception of sites at Leckhampton Hill and Crickley Hill, which are currently considered to be in a favourable condition and stable. Mapping of this formation is generally difficult due to landslipping and cambering.

Reference Sections:

Wotton Hill, Wotton-under-Edge
(SSSI, GCR) (ST 754 939)

Other SSSIs:

Coaley Wood Quarries
(SSSI, GCR) (ST 788 996)
Nibley Knoll - (SSSI, GCR) (ST 744 956)
Haresfield Hill - (SSSI, GCR) (SO 819 088)
Leckhampton Hill - (SSSI, GCR) (SO 9490 1854)
Crickley Hill - (SSSI, GCR) (SO 930 160, SO 929 163)

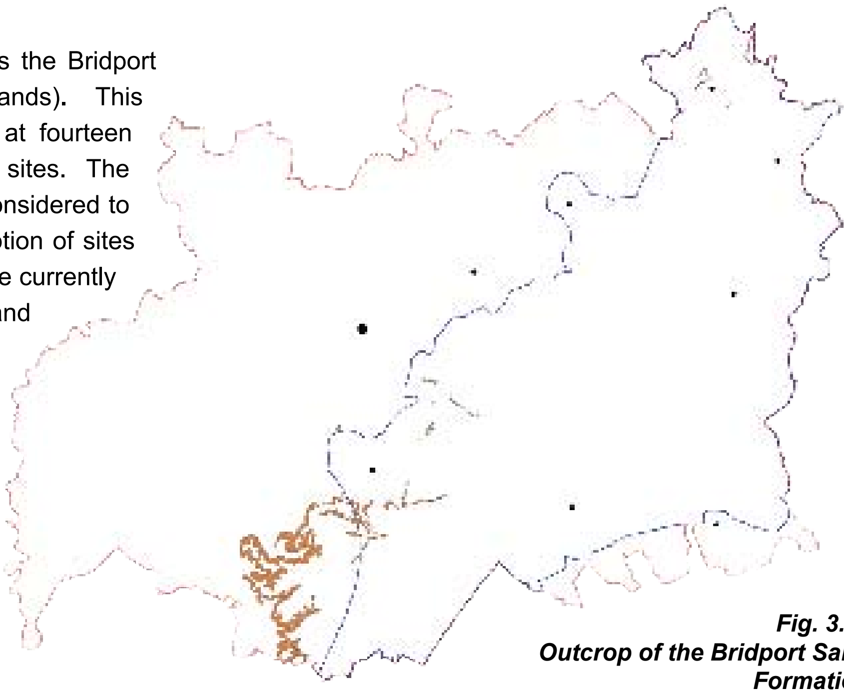


Fig. 3.11
Outcrop of the Bridport Sand Formation

Lithology:

Sandy mudstone and fine-grained sandstone. Grey, weathering yellow or brown, micaceous silt and fine-grained sand, locally with calcite-cemented beds, doggers or lenticular masses ("sand-burrs") and sporadic more argillaceous beds; commonly includes a unit of variably sandy mudstones at the base and in the Worcester Basin area, ironshot marl and limestone ("Cotswold Cephalopod Bed") at the top. The upper boundary is defined by a disconformable contact with the overlying Inferior Oolite Group.

Thickness: Variable, 0-17m in North Cotswolds, 0-10m in Cirencester district.

b. Middle Jurassic - Inferior Oolite Group

The Inferior Oolite Group is an extensive sequence of predominantly marine limestones' making up the main mass and the indented scarp of the Cotswold Hills. Represented within the group are twenty SSSI and GCR sites and numerous RIGS sites. Each of the formations and members are also represented by a type section, and at least one reference section, highlighting the significant geological importance of the group and the individual sites within the Cotswolds. The group is thicker and more developed to the north of the region, reaching approximately 110m (the thickest at outcrop in the U.K), thinning to the east, south and southwest, becoming overlain by the Great Oolite Group. The group is divisible into three formations, which in turn are further subdivided into a number of members. Due to the great thickness and lateral extent of the group, the formations and lithological units are exceptionally well represented, with seventy-five sites within the group, exposing varying formations and members. Leckhampton Hill and Cleeve Hill SSSIs between them, contain the complete, thickest and best inland section of the Inferior Oolite Group in Britain. Sites exposing the Inferior Oolite Group are generally situated on the escarpment and the plateau to the east, forming a broad northeast to southwest trending tract, running through the centre of the Cotswolds. This correlates to the Escarpment, South West Valleys and High Wold landscape characters, based on Cotswold AONB Landscape Character Assessment (Cotswold AONB, 2004). The condition of sites exposed within this group ranges from favourable and stable to unfavourable and declining and also includes some sites that potentially could be lost permanently, such as working quarries earmarked to be back-filled or land-filled when their extraction licence expires.

Type Area:

Cotswolds, Cleeve Cloud, Cleeve Hill - (SSSI, GCR, RIGS) (SO 9840 2549)

Thickness: Averages c.100m in Cheltenham area.

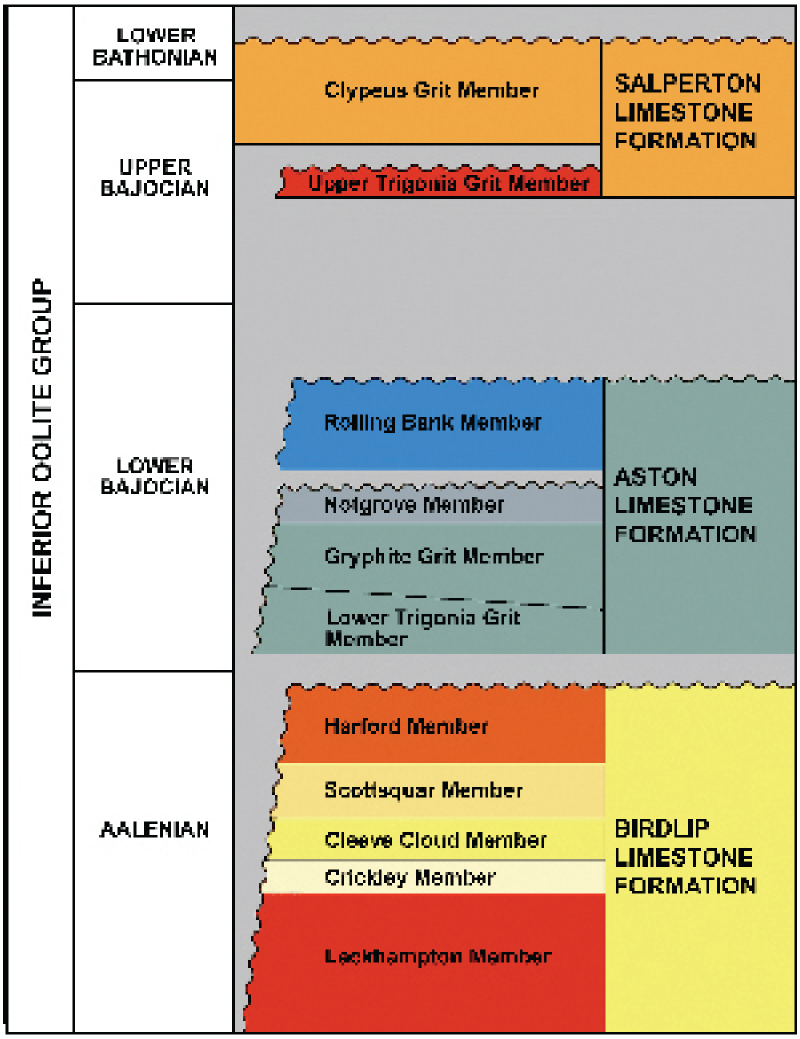


Fig. 3.12
Stratigraphy of the Inferior Oolite Group (Barron et al, 2000)

b.i Birdlip Limestone Formation

The Birdlip Limestone Formation is stratigraphically the lowest and oldest formation of the Inferior Oolite Group. It is extremely well represented, currently exposed at fifty-seven sites. The majority of sites within this formation are located on or close to the escarpment, and along valley sides. The formation is sub-divided into five members, which are also very well represented. All of the fifty-seven sites expose at least two or more members from within the formation and some, such as Cleeve Hill and Leckhampton Hill expose not only this formation but a complete or almost complete section through the succeeding two formations, representing the whole of the Inferior Oolite Group. Within the formation are numerous important reference and type sections. The condition of these sites and exposures vary from unfavourable and declining to favourable and stable or declining. Currently there are numerous sites within this formation that are assessed as in favourable condition which contain excellent, easily accessible exposures.

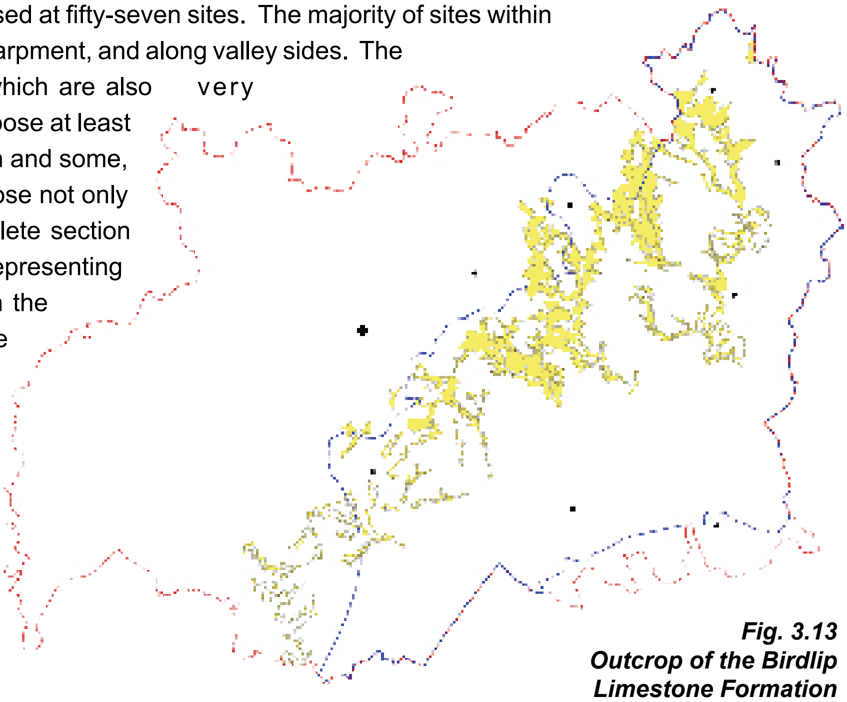


Fig. 3.13 Outcrop of the Birdlip Limestone Formation

Type Section:
Limekiln Quarry & Deadmans Quarry, Leckhampton Hill - (SSSI, GCR, RIGS)
(SO 9490 1854) and (SO 9470 1835 to 9474 1842)

Reference Sections:
Quarries, Cleeve Cloud, Cleeve Hill - (SSSI, GCR, RIGS) (SO 984 254)
Quarries at Crickley Hill - (SSSI, GCR) (SO 930 160, SO 929 163)
Knap House Quarry - (SSSI, GCR) (SO 925 147)
Nibley Knoll - (SSSI, GCR) (ST 744 956)

Thickness: Typically 40 to 46m; type section c.45m (Mudge, 1978a, b), maximum c.74m (Cleeve Hill area).

Leckhampton Member

The Leckhampton Member is well represented, currently exposed at sixteen sites. The most important of these being Limekiln Quarries on Leckhampton Hill, the type section for this member.

Type Section:
Limekiln Quarry, Leckhampton Hill - (SSSI, GCR, RIGS)
(SO 9490 1854)

Reference Sections:
Quarries, Cleeve Cloud, Cleeve Hill - (SSSI, GCR, RIGS) (SO 9840 2549)
Quarries, Crickley Hill - (SSSI, GCR) (SO 927 163)
Haresfield Hill - (SSSI, GCR) (SO 819 088)
Frocester Long Barrow Quarry - (RIGS) (SO 795 016)

Lithology:
Grey, weathering yellow-brown, rubbly, highly bioturbated, ferruginous, finely shell-detrital, medium-grained peloidal and ooidal sandy muddy limestone, ironshot and very shelly in parts, with thin marl beds, basal conglomerate in places. In the Wotton-under-Edge area it includes ironshot limestones at the base (Richardson, 1910). The upper boundary is defined by an upward transition from limestones (as above) into ooidal shell-detrital grainstone (Crickley Member), or a hardground overlain by the Salperton Limestone Formation.

Thickness: Variable, 0-8m in North Cotswolds; type section c. 5.6m, 0-10m in Cirencester district.

Crickley Member

The Crickley Member is very well represented, currently exposed at twenty-five sites. Within these sites is the type section at Crickley Hill and numerous reference sections.

Type Section:
Crickley Hill - (SSSI, GCR) (SO 929 163, SO 929 160)

Reference Sections:
Fiddler's Elbow Quarries - (SO 887 142) (RIGS)
Limekiln Quarry, Leckhampton Hill - (SSSI, GCR)
(SO 9490 1854)
Quarries, Cleeve Cloud, Cleeve Hill - (SSSI, GCR, RIGS) (SO 9840 2549)
BGS Cleeve Common Borehole - (SO 9924 2502)
BGS Stowell Park Borehole - (SP 0835 1176)

Lithology:
Pale grey to yellow-brown limestones; lower part dominated by medium to coarse-grained ooidal shell-fragmental grainstone (Lower Limestone), passing up into rubbly, poorly sorted, shelly, shell-detrital, moderately to highly pisoidal grainstones and packstones (Pea Grit) with thin marl beds. The upper boundary shows an upward transition into ooidal grainstones (Cleeve Cloud Member), in the mid and north Cotswolds; and a non-sequence, marked by a hardground in the south Cotswolds (Mudge, 1978a).

Thickness: Variable, 0-10m in North Cotswolds; type section c.15.7m (Ager, 1969). 0-8m in Cirencester district.

Cleeve Cloud Member

The Cleeve Cloud Member is the best exposed member within the study area. It is well represented, found outcropping at a total of thirty-seven sites. This is one of the most important rock units in the Cotswolds, being used extensively as a building stone, more familiarly known as the Lower Freestone. Sites include the type section and important reference sections for this member.

Type Section:

Deadmans Quarry, Leckhampton Hill - (SSSI, GCR)
(SO 9490 1854)

Reference Sections:

Quarries, Cleeve Cloud, Cleeve Hill - (SSSI, GCR, RIGS) (SO 9840 2549)
Quarries, Crickley Hill - (SSSI, GCR) (SO 929 163, SO 929 160)
Cotswold Hill Quarries - (RIGS) (SP 081 295)
Fiddler's Elbow Quarries - (RIGS) (SO 887 142)
Guiting Quarry - (RIGS) (SP 078 302)
Knap House Quarry - (SSSI, GCR) (SO 925 147)
Jackdaw Quarry - (SSSI, GCR) (SP 077 308)
BGS Cleeve Common Borehole (SO 9924 2502)
BGS Stowell Park Borehole (SP 0835 1176)

Lithology:

Off-white to pale brown medium to coarse-grained oolite grainstone, well bedded and cross-bedded; burrowed and sparsely shell detrital in parts. Locally, highly shell detrital in lower part. Upper boundary defined by a sharp junction, commonly a hardground.

Thickness: Variable, 0-51m in North Cotswolds; (Maximum 51m BGS Cleeve Common Borehole), type section c.25m. 0-40m in Cirencester district.

Scottsquar Member

The Scottsquar Member is also well represented, exposed at twenty-two sites. Formerly divided into the Oolite Marl and Upper Freestone, it is another locally important building stone. Sites include the type section and a number of reference sections for this formation.

Type Section:

Scottsquar Hill Quarry - (RIGS) (SO 8452 0910)

Reference Sections:

Cotswold Hill Quarries - (RIGS) (SP 081 295)
Devil's Chimney Quarry, Leckhampton Hill - (SSSI, GCR) (SO 9470 1838)
Fiddler's Elbow Quarries - (RIGS) (SO 887 142)
Guiting Quarry - (RIGS) (SP 078 302)
Knap House Quarry - (SSSI, GCR) (SO 925 147)
Jackdaw Quarry - (SSSI, GCR) (SP 077 308)
Frith Quarry - (SSSI, GCR) (SO 8684 0824)
Leigh's Quarry - (SSSI, GCR) (SO 826 026)
Notgrove Station Railway Cutting - (SSSI, GCR)
(SP 0939 2129)

Lithology:

Pale grey and brown medium to coarse-grained peloid, ooid and shell-fragmented packstone and grainstone (Upper Freestone), with beds and lenses of grey to white, commonly highly fossiliferous marl/carbonate mudstone (Oolite Marl). These occur throughout the succession, though particularly in the lower part. Fauna dominated by brachiopods; characteristic fossils include the plicate terebratulid brachiopod Plectothyris.

The Upper boundary shows upward rapid transition to the Harford Member, or a hardground overlain by Aston Limestone Formation or Salperton Limestone Formation.

Thickness: Variable, 0-10m in North Cotswolds; type section 2.4m (Mudge, 1978a), 0-30m in Cirencester district.

Cleeve Cloud and Scottsquar Members of the Birdlip Limestone Formation exposed at Deadmans Quarry, Leckhampton Hill

Harford Member

The Harford Member is the uppermost unit of the Birdlip Limestone Formation, occupying a restricted area in the North Cotswolds. Exposures of this member are generally poorly represented. This member is exposed at nine sites. Amongst these sites is the type section for the member and a number of reference sections.

Type Section:

Harford Railway Cutting - (SSSI, GCR) (SP 1360 2184)

Reference Sections:

Aston Farm Railway Cutting - (RIGS) (SP 1441 2135)
Cotswold Hill Quarries - (RIGS) (SP 081 295)
Guiting Quarry - (RIGS) (SP 078 302)
Jackdaw Quarry - (SSSI, GCR) (SP 077 308)
Notgrove Station Railway Cutting - (SSSI, GCR) (SP 0939 2129)
The Holt Quarry - (SP 148 353) (no current designation)

Lithology:

Interbedded yellow silty fine-grained sand, cemented in parts (Harford Sands), grey and brown mudstone, shelly and sandy in parts (Snowshill Clay and Naunton Clay) and variably sandy and ooidal limestone (Tilestone). The succession is characterised by rapid lateral facies transitions and a mix of fully marine and quasi-non-marine facies. The upper boundary is defined by sharp contact, generally a hardground, overlain by either the Aston or Salperton Limestone Formations. Generally restricted to the North Cotswolds and based on mapping in the Moreton-in-Marsh district, the succession appears laterally highly variable and the previously named units are of little stratigraphic value (Parsons 1976; Mudge 1978).

Thickness: Variable, 0-14m in North Cotswolds; type section c.3m, 0-2m in Cirencester district.

b.ii Aston Limestone Formation

The Aston Limestone Formation is also extremely well represented, currently exposed at twenty-three sites. The type section for this formation is Harford Railway Cutting. The formation is further divisible into four members, which again are very well represented, with the exception of the Rolling Bank Member. This member comprises three units, the Whitchellia Grit, the Bourguetia Beds and the Phillipsiana Beds. Exposures within this member are very limited. The latter two are unique to the Cotswolds and exceptionally rare, only exposed at Rolling Bank Quarry, Cleeve Hill, where it is the type section for the Rolling Bank Member. The condition of these sites is variable, between favourable and unfavourable.

Type Section:

Harford Railway Cutting - (SSSI, GCR) (SP 1360 2184)

Reference Sections:

Aston Farm Railway Cutting - (SP 1441 2135) (RIGS)
Quarries, Cleeve Cloud, Cleeve Hill - (SO 9840 2549) (SSSI, GCR, RIGS)
Deadmans Quarry, Leckhampton Hill - (SO 9477 1847 to 9498 1847) (SSSI, GCR)
Swift's Hill - (SO 878 067) (SSSI, GCR)
Chedworth Tumulus Railway Cutting - (SP 0507 1392 to 0500 1404) (RIGS)

Thickness: Variable, 0-22m in North Cotswolds; type section up to c.6.8m, 0-15m in Cirencester district.

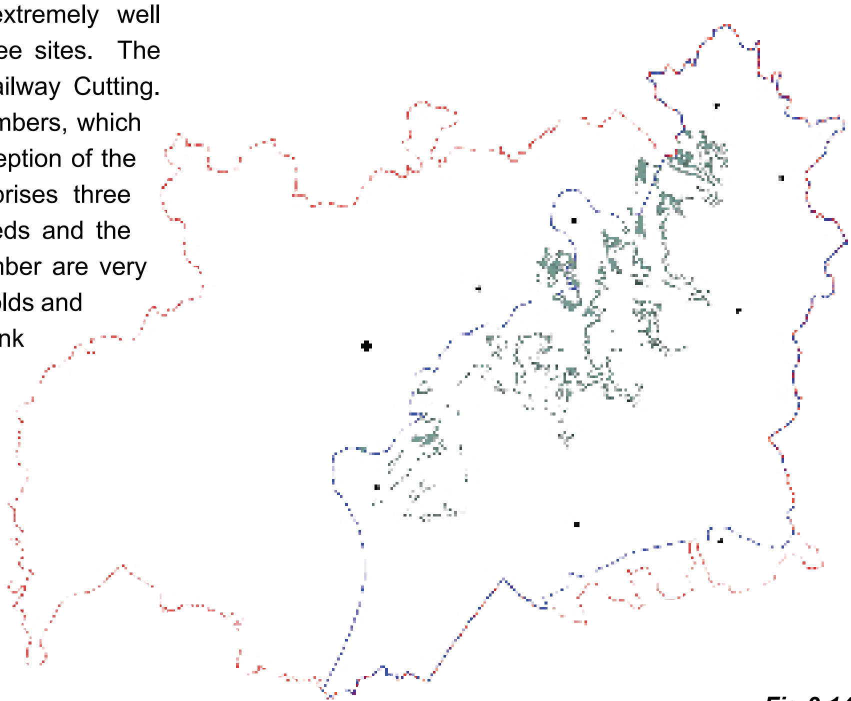


Fig.3.14
Outcrop of the Aston Limestone Formation

Lower Trigonia Grit Member

The Lower Trigonia Grit Member is well represented, exposed at seventeen sites. The type section and a number of important reference sections are represented within these sites.

Type Section:

Deadman's Quarry, Leckhampton Hill
(SSSI, GCR) (SO 9477 1847 to 9498 1847)

Reference Sections:

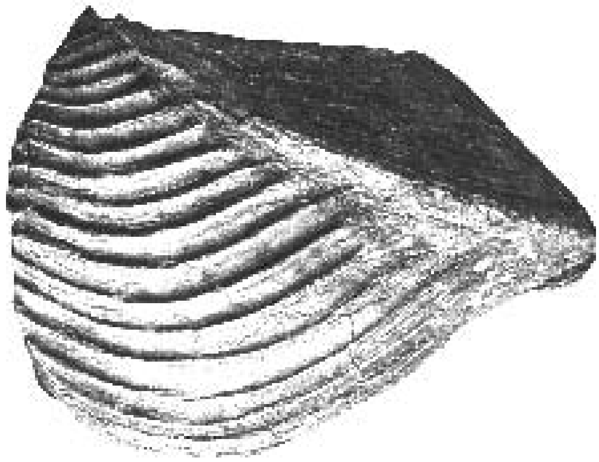
Harford Railway Cutting - (SSSI, GCR) (SP 1360 2184 to 1404 2166)
Aston Farm Railway Cutting - (RIGS) (SP 1441 2135)
Jackdaw Quarry - (SSSI, GCR) (SP 077 308)
Swift's Hill - (SSSI, GCR) (SO 878 067)
Chedworth Tumulus Railway Cutting - (RIGS)
(SP 0507 1392 to 0500 1404)
Frith Quarry - (SSSI, GCR) (SO 8684 0824)
Fort Quarry - (SSSI, GCR) (SO 850 040)
Catsbrain Quarry - (RIGS) (SO 866 115)

Lithology:

Grey speckled with orange-brown, very shelly and shell-detrital, moderately sandy, peloid wackestones, packstones and grainstones with thin marl and sand beds, some shelly; commonly some ferruginous peloids (ironshot); commonly pebbly at base. Passes northwards into marly, ironshot, highly conglomeratic limestone, with pebbles of sandy limestone derived from the underlying Harford Member (Parsons, 1976). Characteristic fauna includes bivalves (notably trigoniids), brachiopods, corals and the colonial serpulid Sarcinella. The upper boundary is defined by an upward transition from limestone as above, into sandier, more coarsely shell-detrital, less ironshot limestones (Gryphite Grit Member), or hardground overlain by the Salperton Limestone Formation.

Thickness: Typically 1 to 2m; type section 2.2m; maximum c.3m.

Gryphaea sublobata, type fossil for the Gryphite Grit Member



Trigonia costata, type fossil for the Trigonia Grits

Gryphite Grit Member

The Gryphite Grit Member is well represented, currently exposed at seventeen sites. Type and reference sections for this member are represented. Site condition is variable, from unfavourable to favourable.

Type Section:

Deadman's Quarry, Leckhampton Hill
(SSSI, GCR) (SO 9477 1847 to 9498 1847)

Reference Sections:

Harford Railway Cutting
(SSSI, GCR) (SP 1360 2184 to 1404 2166)
Aston Farm Railway Cutting - (RIGS) (SP 1441 2135)
Catsbrain Quarry - (SO 866 115) (RIGS)
Swift's Hill - (SSSI, GCR) (SO 878 067)
Chedworth Tumulus Railway Cutting - (RIGS) (SP 0507 1392 to 0500 1404)

Lithology:

Grey and brown, rubbly, shelly, variably sandy shell fragment and peloid grainstones, packstones and wackestones with thin mudstone, marl and sand beds; some ferruginous peloids. Characteristic fauna includes the brachiopod Lobothryris buckmani (Davidson) particularly in the lower part (Buckmai Grit), abundant Gryphaea bilobata Sowerby and belemnites particularly in the upper part (Gryphite Grit). Upper boundary defined by an upward transition in to sparsely shelly peloidal and ooidal grainstones (Notgrove Member), or hardground, overlain by the Salperton Limestone Formation.

Thickness: Typically 3 to 5m; type section 6.6m (Leckhampton Hill); maximum c.7m.

Notgrove Member

The Notgrove Member is moderately represented, currently exposed at eleven sites. Among these sites is the type section for the member and a number of reference sections. Exposures at these sites vary from excellent (type section) to limited, poor outcrops. The condition of these sites is also variable, from favourable to unfavourable. The member is commonly cross-bedded, with a sparse fauna, shell and shell debris are restricted to the lower beds. This lack of fauna has made this an important local building stone. The top of the member is typically well-developed, with a planed, oyster-encrusted hardground with borings.

Type Section:
Notgrove Railway Cutting (SSSI, GCR) (SP 0845 2090)

Reference Sections:
Cold Comfort Quarry (not surveyed) (SO 9961 1854)
Chedworth Tumulus Railway Cutting (RIGS) (SP 0507 1392 to 0500 1404)
Harford Railway Cutting (SSSI, GCR) (SP 1360 2184 to 1404 2166)

Lithology:
Pale brownish grey, cross-bedded, medium to coarse-grained peloidal and ooidal grainstone, typically poorly sorted or bimodal; shells and shell debris rare, except in lowest beds. The upper boundary is defined by a hardground, overlain by the Rolling Bank Member or hardground overlain by Salperton Limestone Formation.

Thickness: Variable, 0-13m in North Cotswolds; type section 3.9m, 0-10m in Cirencester district.

Rolling Bank Member

The Rolling Bank Member is the youngest member of the Aston Limestone Formation. The complete member comprises the combined Whitchellia Grit, Bourguetia Beds and Phillipsiana Beds. Not only is it unique to the Cotswolds but to England also, the complete member being exposed at Rolling Bank Quarry, Cleeve Hill, confined to the Cleeve Hill Syncline. Only the lower beds, the Whitchellia Grit, is found outside of the Cleeve Hill Syncline, in the Cirencester district. The member is well exposed at Rolling Bank Quarry, which is in a favourable and stable condition. There are relatively few good exposures of the Witchellia Grit and where it is exposed it is generally considered to be in an unfavourable condition.

Type Section:
Rolling Bank Quarry, Cleeve Hill (SSSI, GCR)
(SO 9871 2668)

Reference Sections:
Cold Comfort Quarry (SO 9961 1854)

Lithology:
Grey rubbly limestones; in lower part (Witchellia Grit) yellowish, shelly, sandy, ooidal and ironshot with brachiopods and rare ammonites including Witchellia; in middle part (Bourguetia Beds) very shelly with bivalves and gastropods including Bourguetia saemanni (Oppel); in upper part (Phillipsiana Beds) hard, sandy and shelly with brachiopods including Terebratula phillipsiana (Walker). Upper boundary is defined by a hardground, overlain by the Salperton Limestone Formation.

Thickness: 0-8.5m in North Cotswolds; 8.5m at type section (Rolling Bank Quarry), 0-1m in Cirencester district.

b.iii Salperton Limestone Formation

The Salperton Limestone Formation is the uppermost formation of the Inferior Oolite Group. The formation comprises two members, the Upper Trigonia Grit Member and the Clypeus Grit Member, both of which are very well represented, together exposed at thirty-five sites. The uppermost member, the Clypeus Grit, is the most laterally extensive unit of the Inferior Oolite Group. The formation generally rests unconformably on the Rolling Bank Member, where present, or progressively oversteps the lower members of the Inferior Oolite Group. Site condition is variable, from unfavourable to favourable.

Type Section:
Notgrove Railway Cutting - (SSSI, GCR)
(SP 0845 2090)

Reference Sections:
Chedworth Woods Railway Cutting - (RIGS)
(SP 0450 1443 to 0462 1438)
Harford Railway Cutting - (SSSI, GCR) (SP 1360 2184 to 1404 2166)
Hawkesbury Quarry - (SSSI, GCR) (ST 7711 8727)
Rolling Bank Quarry, Cleeve Hill - (SSSI, GCR) (SO 9871 2668)

Thickness: Variable, 5-18m in North Cotswolds; type section 13m, 8-20m in Cirencester district.

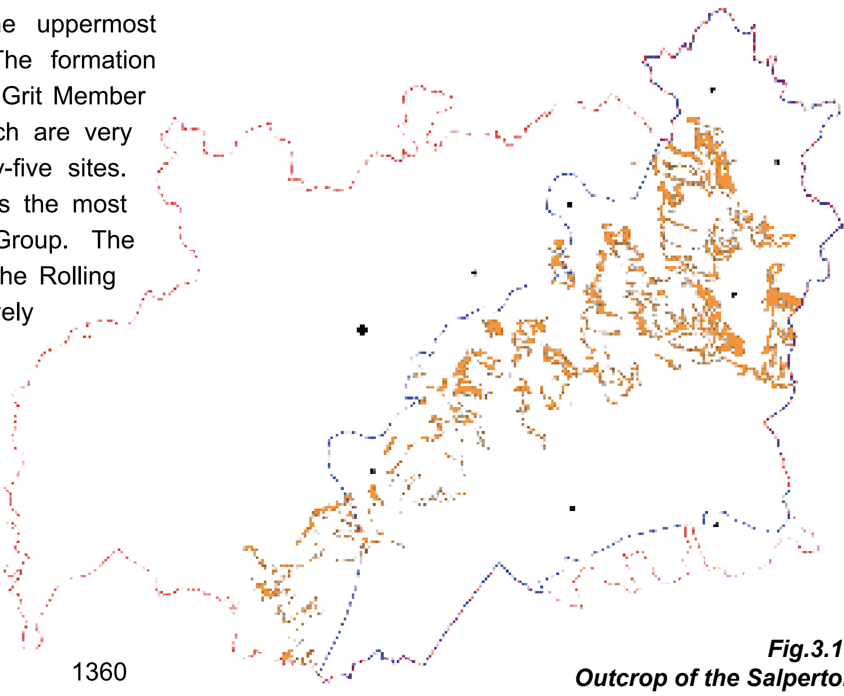


Fig.3.15
Outcrop of the Salperton Limestone Formation

Upper Trigonia Grit Member

The Upper Trigonia Grit is extremely well represented, exposed at thirty-three sites. The condition of these sites is variable from unfavourable to favourable, with the best exposures at Cleeve and Leckhampton Hills and at Notgrove Railway Cutting, the type section for the member.

Type Section:

Notgrove Railway Cutting
(SSSI, GCR) (SP 0847 2091 to 0866 2099).

Reference Sections:

Chedworth Woods Railway Cutting (RIGS) (SP 0450 1443 to 0462 1438 and SP 0510 1375 to 0539 1290)
Fort Quarry (SSSI, GCR) (SO 850 040)
Harford Railway Cutting (SSSI, GCR) (SP 1360 2184 to 1404 2166)
Hawkesbury Quarry (SSSI, GCR) (ST 7711 8727)
Knap House Quarry (SSSI, GCR) (SO 925 147)
Leigh's Quarry (SSSI, GCR) (SO 826 026)
Rolling Bank Quarry, Cleeve Hill
(SSSI, GCR) (SO 9871 2668)

Lithology:

Very hard, poorly but thickly-bedded, grey and brown, very shelly, shell-detrital and moderately ooidal grainstone and packstone. Characteristic fauna includes trigoniid bivalves, commonly as moulds, and brachiopods. Upper boundary indicated by upward change from limestone as above to fine to coarse-grained ooidal, peloidal/pisoidal and shell-detrital packstone to grainstone (Clypeus Grit member); commonly a non-sequence marked by a hardground.

Thickness: Variable, 0-3m in North Cotswolds; type section 1.05-1.2m, 0-5m in Cirencester district.

Clypeus Grit Member

The uppermost member of the Salperton Limestone Formation is the Clypeus Grit Member. This can be seen exposed at twenty-five sites and is extremely well represented. The best exposures of this member are to be found at Rolling Bank Quarry, Cleeve Hill, Chedworth Railway Cutting and at the type section, Notgrove Railway Cutting. These sites are currently in favourable condition, the others are in varying conditions from unfavourable to favourable.

Type section:

Notgrove Railway Cutting
(SSSI, GCR) (SP 0847 2091 to 0866 2099)

Reference Sections:

Chedworth Woods Railway Cutting
(RIGS) (SP 0450 1443 to 0462 1438)
Harford Railway Cutting
(SSSI, GCR) (SP 1360 2184 to 1404 2166)
Hawkesbury Quarry (SSSI, GCR) (ST 7711 8727)
Leigh's Quarry (SSSI, GCR) (SO 826 026)
Rolling Bank Quarry, Cleeve Hill
(SSSI, GCR) (SO 9871 2668)

Lithology:

Pale grey to pinkish brown rubbly, medium to coarse-grained ooidal, peloidal and shell detrital packstone to grainstone, with large orange-skinned peloids/pisoids and aggregate grains; common whole shells especially in the upper part. Characteristic fauna includes the large echinoid Clypeus ploti (Salter) large myacean bivalves and terebratulid brachiopods (Stiphrothyris). From Stroud southwards, includes coral-rich limestone (Upper Coral Bed) at base. The upper boundary is defined by an upward change to mudstone (Fuller's Earth Formation) in southwest or into fine to medium-grained grainstone (Chipping Norton Limestone Formation), in the northeast. Generally transitional, but locally marked by a hardground. The Clypeus Grit Member is the most laterally extensive unit within the Inferior Oolite Group in the Cotswolds.

Thickness: Variable, 5-16m in North Cotswolds; type section 10.5-12m, 7-16m in Cirencester district.

Brownstone Quarry, Leckhampton Hill
A recently improved exposure showing the unconformity between the Notgrove Member (Aston Limestone Formation) and the Upper Trigonia Grit Member (Salperton Limestone Formation)

c. Middle Jurassic - Great Oolite Group

The Great Oolite Group is a series of shallow marine limestones, mudstones, clays and grits, unconformably deposited on top of the Inferior Oolite Group. forming the scarp in the south and much of the uplands to the southeast of the area. Outcrops occupy a large area to the southeast of the plateau, in a north-east to south-west trending belt, but are generally poorly to moderately represented, exposed at a total of thirty-three sites. This area broadly corresponds to the High Wold Dip Slope and Dip Slope Lowland landscape characters, based on the Cotswold AONB Landscape Character Assessment. The Group can be divided into seven formations, some of which can be further subdivided into members. Unlike the Lias Group and the Inferior Oolite Group, type sections and reference sections within the Cotswolds are limited, as much of the work on the group has been based outside of the study area around Bath.

Thickness: North Cotswolds (Moreton-in-the-Marsh district) c.45-55m. South Cotswolds (Cirencester district) c.60 to 100m.

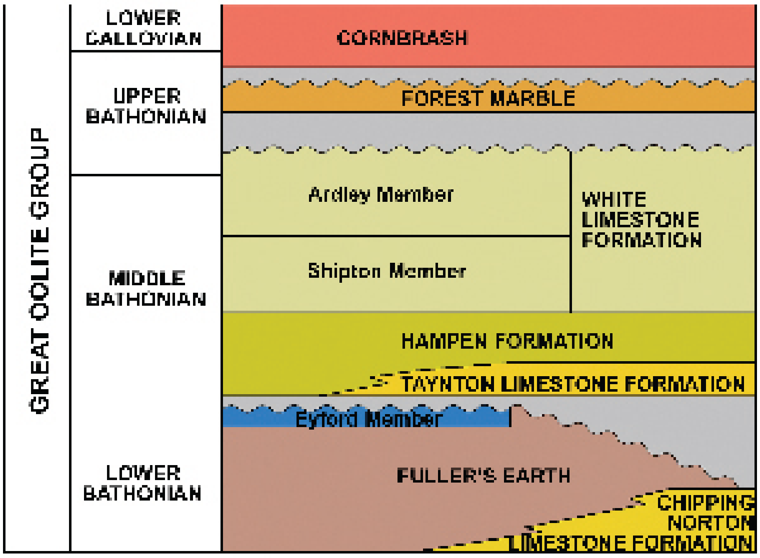


Fig.3.16 Stratigraphy of the Great Oolite Group
(Barron et al, 2000)

c.i Chipping Norton Limestone Formation

The Chipping Norton Limestone Formation is the oldest formation of the Great Oolite Group. Outcrops are limited to just seven sites in the northeast of the study area, capping the high ground to the east of the Vale of Bourton, in the Moreton-in-Marsh district. Exposures are generally good, with most of the sites being currently in favourable condition as a number of them are active working quarries.

Type Section:
None in Cotswolds (Oxfordshire County Council Quarry, Chipping Norton).

Reference Sections:
None in Cotswolds (Ditchley Road Quarry, Charlbury).

Other reference Sections:
Hornsleasow Quarry (SSSI, GCR)
(SP 131 322)
New Park Quarry (SSSI, GCR)
(SP 175 282)

Lithology:
Basal unit of the Great Oolite Group in the north east Cotswolds. This formation exhibits considerable lithological variation. Typically; limestone, off-white to pale brown, fine to medium-grained ooidal and coated peloidal grainstone, with common fine burrows, medium to coarse-grained shell debris and flakes of greenish-grey mudstone and dark lignite and minor amounts of fine sand. Thick-bedded and cross-bedded or massive, weathering to flaggy or platy. Thin shell-detrital and ooidal marl and mudstone intercalations in places. Becoming very sandy eastwards. Locally a mudstone bed (‘Roundhill Clay’ of Richardson, 1929) up to c.1m thick occurs at the base. Upper boundary with a rapid passage upwards into mudstone-dominated Fuller’s Earth Formation.

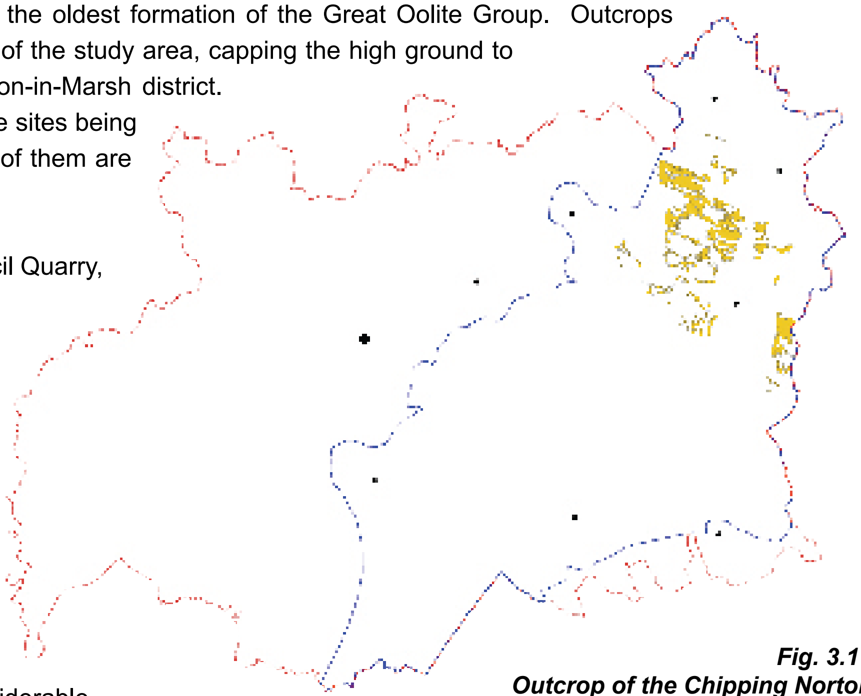


Fig. 3.17 Outcrop of the Chipping Norton Limestone Formation

Thickness: Variable, 0-16m in North Cotswolds, 0-5m in Cirencester district.

c.ii Fuller's Earth Formation

The Fuller's Earth Formation is generally considered as the basal unit of the Great Oolite Group in much of the region, except to the northeast, where the Chipping Norton Limestone Formation is developed. The lower part of the formation comprises predominantly grey mudstones (Lower Fuller's Earth), the upper part sandy limestones and sandstones (Eyford & Througham Member). In the north Cotswolds, the Lower Fuller's Earth thins rapidly and passes into the Eyford Member between Minchinhampton and Cirencester. It is absent north of Condicote and east of the Moreton axis (Green, 1992), where it is replaced by the Chipping Norton Limestone Formation. The Upper Fuller's Earth is absent in the north Cotswolds. Outcrops are generally limited to working quarries or steep valley slopes to the northeast of the Cotswolds and it is this formation that is responsible for the steep-sided profile to these valleys and the association with landslipping.

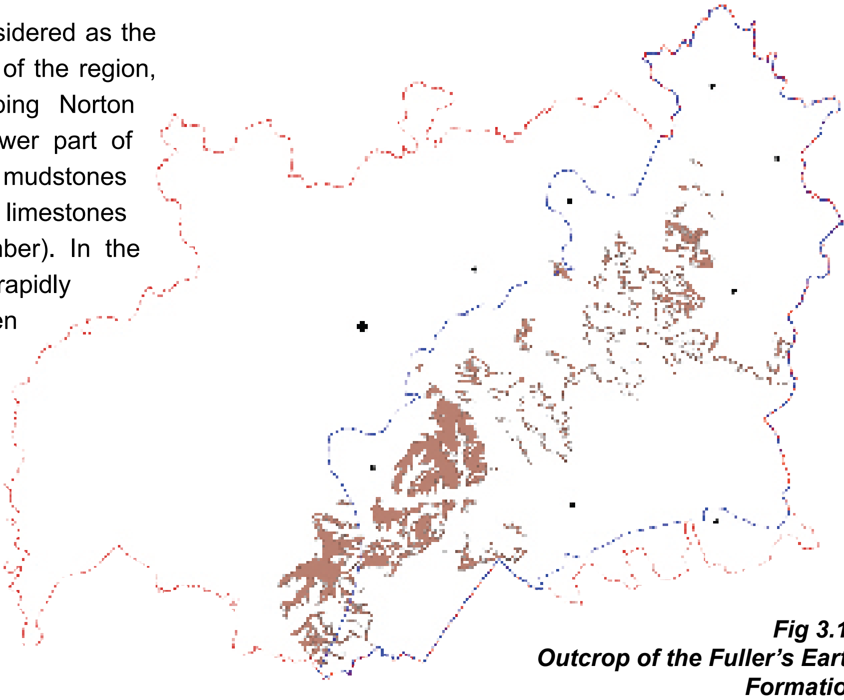


Fig 3.18
Outcrop of the Fuller's Earth Formation

Type Section:
None in Cotswolds
(Horsecombe Vale No.15 Borehole, Bath ST76SE/24)

Reference Section:
BGS Stowell Park Borehole
(Reg. No. SP 01 SE/1) (SP 0835 1176)

Lithology:
Calcareous silty mudstone with some units of limestone.

Thickness: Variable, 0-19m in North Cotswolds, 0-35m in Cirencester district, c.20-30m in Malmesbury area.

Lower Fuller's Earth

The Lower Fuller's Earth (Sharps Hill Formation) is the basal section of the formation and is restricted to just five sites. Several of these exposures are well displayed as they are in working quarries, others, however, are in poor condition.

Type and Reference Sections:
None in the Cotswolds.

Lithology:
Olive-grey, silty, calcareous mudstones with thin intervals of argillaceous limestone and oyster-rich mudstones.

Thickness: Variable, 0-10m.

Eyford Member and Througham Member

The Eyford Member (Cotswold Slates) and Througham Member constitute the upper part of the Fuller's Earth Formation in the region. These are both locally important, being used extensively as roofing slates. Exposures are moderately represented at four sites, including the former working quarry, Eyford Hill Pits, where it is the type section for the Eyford member. It is better exposed at Huntmans and Grange Hill quarries, both currently still working.

Type Section:
Eyford Hill Pits (RIGS) (SP 138 255)

Lithology:
Pale grey, fissile, finely ooidal grainstone interbedded with grey, laminated fissile calcareous sandstone, locally decalcified to loose orange-brown sand, with minor beds of shelly and shell-fragmental limestone, marl or fissile mudstone.

Thickness: Variable, 0-9m in North Cotswolds; 6-7m at type section, 0-5m in Cirencester district.

The SSSI section at Huntsmans Quarry.
This site exposes the Eyford Member of the Fuller's Earth Formation which is still worked for roofing tilestone in the present day quarry

c.iii Taynton Limestone Formation

The Taynton Limestone Formation (formerly the Taynton Stone), overlies the Eyford or Througham Members in most of the region. Around the Cirencester district, it is found extensively at outcrop in steep-sided valleys such as those of the rivers Windrush in the northeast and of the Coln, Churn and Leach in the central area. Around the Sevenhampton area, it passes laterally into the Hampen Formation. This formation is poorly to moderately represented, outcropping at seven sites, although exposures are generally poor, with the exception of those displayed in working quarries.

Reference Sections:

Hampen Railway Cutting (SSSI, GCR) (SP 062 205)

Farmington Quarry (RIGS) (SP 130 168)

Lithology:

White to pale brown, typically well-sorted medium to coarse-grained, moderately to highly shell-detrital ooidal grainstone, locally fine to very coarse-grained; medium to thickly well-bedded and cross-bedded, with thin shell-detrital marl seams and locally calcareous sandstone beds.

Thickness: Variable, 0-7m in North Cotswolds, 0-15m in Cirencester district.

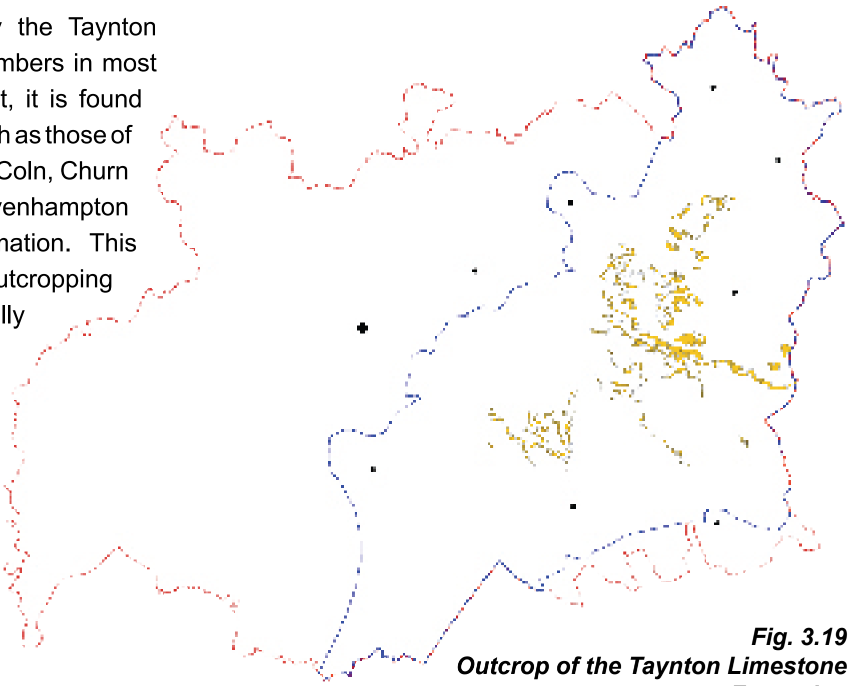


Fig. 3.19
Outcrop of the Taynton Limestone Formation

c.iv Hampen Formation

Following the Taynton Limestone Formation is the Hampen Formation (roughly equivalent to the Minchinhampton Beds in the Stroud/Minchinhampton area). Exposures are displayed in narrow outcrops along river valleys in the Cirencester district and in the north Cotswolds exposure is limited to outcrops to the west of the Vale of Moreton. The formation is generally poorly represented and exposed, limited to just six sites but does include the type section for the formation.

Type Section:

Hampen Railway Cutting (SSSI, GCR) (SP 062 205)

Reference Sections:

Chedworth Tumulus Railway Cutting (RIGS) (SP 0507 1392 to 0500 1404)

Daglingworth Quarry (RIGS) (SP 001061)

Lithology:

Limestones with subordinate interbedded marls; limestones characteristically grey to brown, thinly bedded, fine to very fine-grained, well sorted, ooidal grainstone to packstone, commonly slightly sandy or silty, with small-scale cross-bedding.

Thickness: Variable, 2-9m in North Cotswolds, 1-20m in Cirencester district.

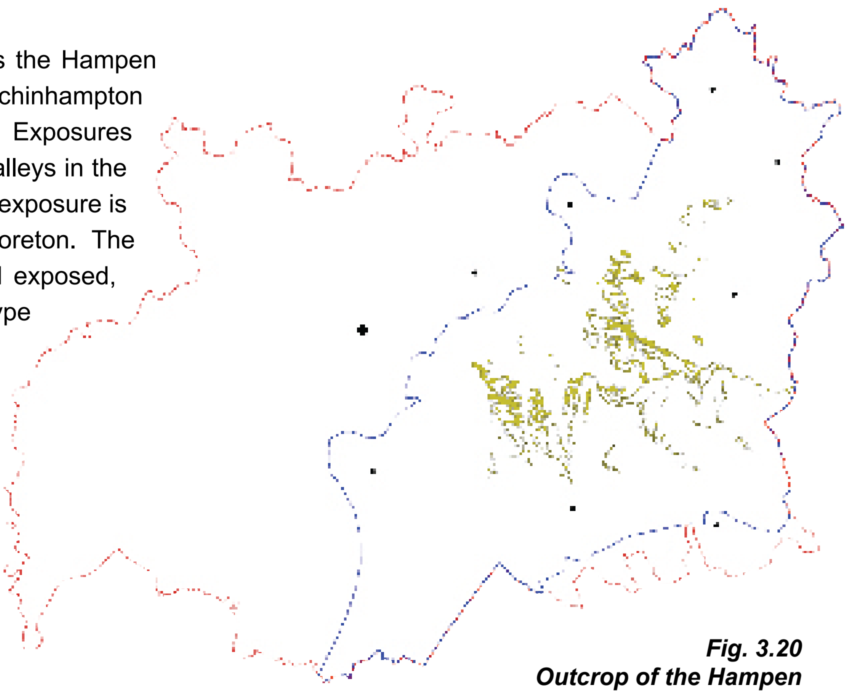


Fig. 3.20
Outcrop of the Hampen Formation

c.v White Limestone Formation

The White Limestone Formation is moderately represented and limited to outcrops at twenty-five sites. There are limited exposures in the north Cotswolds, between Hampen and Condicote but in the central Cotswolds, to the north of the Cirencester district, the formation occupies an extensive area and exposures are far more wide-spread. Here the formation forms a dissected plateau and is divided into the Shipton, Ardley and Signet Members.

Exposures are generally poor and considered in unfavourable condition.

Type/Reference Sections:

There are no type or reference sections for this formation within the Cotswolds.

Lithology:

Pale grey to off-white or yellowish limestone, peloidal wackstones and packstones with subordinate ooidal and shell fragmental grainstones; recrystallised limestone and/ or hardgrounds at some levels; rarer sandy limestone, argillaceous limestone, marl and mudstone/clay. Comprises Shipton, Ardley, Signet and Bladon Members (Bladon Member does not outcrop within the study area).

Thickness: Variable, 10-25m.

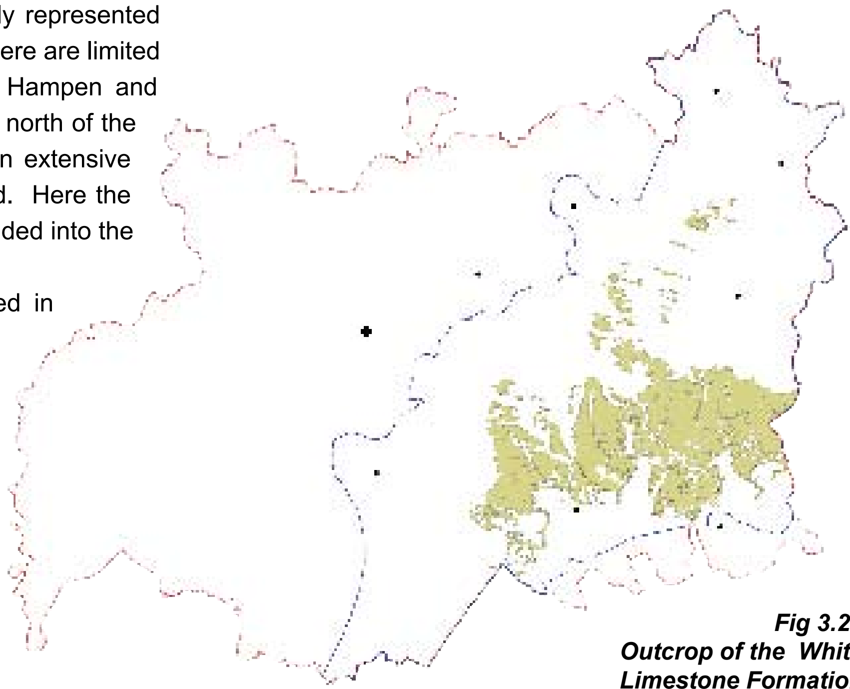


Fig 3.21 Outcrop of the White Limestone Formation

Shipton Member

The Shipton Member (Dodington Ash Rock in the Stroud/ Minchinhampton area), is the oldest member of the formation and is poorly represented, found at just five sites. Exposures are, however, relatively good, such as those at Fosse Cross and Daglingworth quarries. At Stony Furlong railway cutting, the whole of the member is present, making it the most important section in the White Limestone Formation in the region, although much of the exposure is currently obscured.

Type/Reference Sections:

There are no type or reference sections within the Cotswolds for this member.

Lithology:

Pale grey to off-white or yellowish limestone, peloidal wackstones and packstones with subordinate ooidal and shell fragmental grainstones; recrystallised limestone with beds of argillaceous limestone, marl and mudstone/clay.

Thickness: Variable, 4-10m.

Ardley Member

The Ardley Member (Athelstan Oolite and Combe Down Oolite Member in the Stroud/Minchinhampton area) is also poorly represented, exposed at ten sites. Exposures vary in condition, from unfavourable to favourable, with the best of these being at Daglingworth Quarry, where almost the whole of the member is exposed. Here and in this area the Dagham Stone hardground horizons are particularly well developed.

Type/Reference Sections:

None in the Cotswolds.

Lithology:

Pale grey to off-white or yellowish limestone, peloidal wackstones and packstones with common ooidal and shell fragmental grainstones, occuring particularly to the south-west of the type area; recrystallised limestone with beds of argillaceous limestone, sandy limestone, marl and mudstone/ clay at some levels.

Thickness: Typically 9-10m where fully developed, thickening to c.12m in the Cirencester district.

Signet Member

The Signet Member (equivalent to the Bladon Member of Oxfordshire, locally the Coppice Limestone in the Stroud/ Minchinhampton area) is the uppermost member of the White Limestone Formation. Outcrops are poorly represented, limited to exposures at ten sites, the condition of these exposures being generally considered unfavourable. The Coppice Limestone is limited in occurrence, restricted to south of the Minchinhampton area and therefore poorly represented, found at just three sites.

Type Section:

Job's Lane, Signet (SP 245 102) Not within the study area.

Coppice Limestone Type Section (RIGS) (ST 8080 9059)

Reference Section:

Wiggold Railway Cuttings (RIGS) (SP 0449 0519)

Lithology:

Typically brownish grey sandy or clayey peloidal wackstone, commonly with shell-fragments and lignite, associated with green and brown mudstone/clay; also shell-fragmental ooidal grainstones, brown sandy limestone and white carbonate mudstone and coralliferous marl, resting on hardground or eroded surface.

Thickness: Variable, 0-11m, more commonly 2-3m.

c.vi Forest Marble Formation

The Forest Marble Formation rests on the eroded surface of the White Limestone Formation. The thickness of this formation is variable within the Cotswolds. It is limited to exposures at eleven sites, with only a few outcrops in the north Cotswolds. Around and to the northeast of Cirencester, outcrops are more widespread, occupying an extensive area. Exposures vary in condition, but would generally be considered as being in unfavourable condition. This formation has been extensively worked in the past for walling and paving stones and roofing tilestones.

Type/Reference Sections:
There are no reference or type sections for this formation in the Cotswolds.

Lithology:
Mudstone with lenticular beds of limestone (shell-fragmental, ooidal grainstone and sandy limestone, often argillaceous, typically cross-beddedand forming banks and channel-fills), especially in lower part.

Thickness: Variable, c.6m in North Cotswolds, 10-25m in Cirencester district.

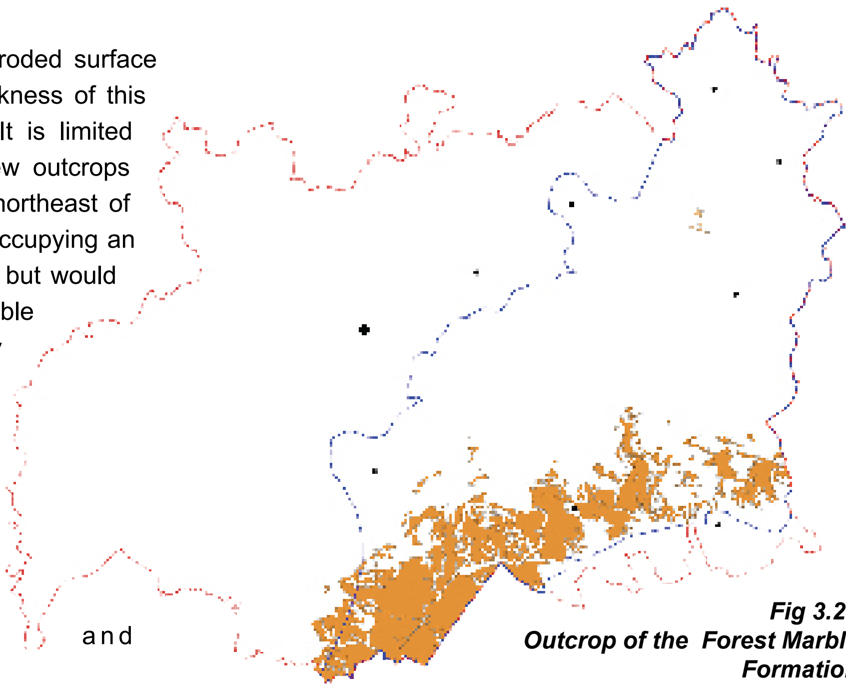


Fig 3.22
Outcrop of the Forest Marble Formation

c.vii Cornbrash Formation

The Cornbrash Formation is the uppermost formation of the Great Oolite Group, and was traditionally divided into the Upper and Lower Cornbrash. It rests disconformably on the eroded upper surface of the Forest Marble Formation. This formation is poorly represented, exposed at only two sites within the Cotswolds, the condition of these sites is considered as unfavourable. This is the least represented unit from within the Cotswolds. A literature search has revealed several other sites exposing the formation, which have now been identified and will be surveyed with the data added to GGT records.

Type/Reference Sections:
There are no type or reference sections for this formation in the Cotswolds.

Lithology:
Shell-fragmental calcarenite limestone, generally thinly-bedded, bluish-grey hearted, weathering to brown and rubbly.

Thickness: Variable, c.3m in North Cotswolds, 2-6m in Cirencester district.

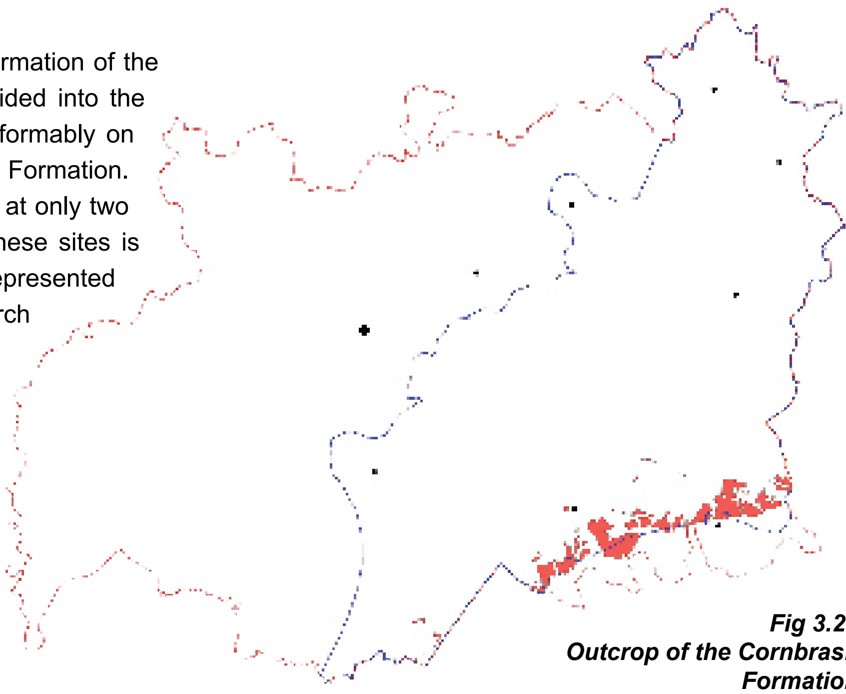


Fig 3.23
Outcrop of the Cornbrash Formation

d. Upper Jurassic - Ancholme Group

The Ancholme Group consists of the Kellaways Formation (Lower and Upper), and the Oxford Clay Formation. It is poorly represented, exposed at six sites and is restricted to the south-east corner of Gloucestershire, to the south-east of Cirencester and to the east of Fairford, outcropping in small, isolated patches. The outcrops correspond to the Dip Slope Lowland and a transition into the Upper Jurassic Oxford Clay Vale, based on Cotswold AONB landscape Character Assessment.

Type/Reference Sections:

There are no type or reference sections for the group or its formations in the Cotswolds.

Thickness: Variable, c.3m in the North Cotswolds (Oxford Clay Member absent), up to c.35m in the Cirencester district.

FIG 3.24
Stratigraphy of the Ancholme Group (Upper Jurassic)

d.i Kellaways Formation

The Kellaways Formation is now divisible into the lower unit, the Kellaways Clay Member and upper, the Kellaways Sand Member. This formation is poorly represented and relatively rare in the Cotswolds, exposed at just four sites. There is just one exposure of the clay member in the north Cotswolds, the others are restricted to the south of the Cirencester district around the Fairford area. These exposures are considered to be in favourable condition. The sand member is only exposed at one site in the South Cerney area and is considered in an unfavourable condition.

Type/Reference Sections:

There are no type or reference sections for the group or its formations in the Cotswolds.

Lithology:

Various lithologies, with diachronous boundaries; generally lower part clay, upper part fine sands and silts with some soft sandstones and doggers locally at or near the top.

Thickness:

North Cotswolds: Clay Member: up to 3m, Sand member: not present.

Cirencester district: Clay member: c.2-4m, Sand Member: c.5-9m.

d.ii Oxford Clay Formation

The Oxford Clay Formation, like the Kellaways Formation, is relatively rare in the Cotswolds and is restricted to the far south-east of the Cotswolds, where only the basal part is present. The formation is moderately represented, exposed at just three sites. The condition of the exposures is generally considered to be in an unfavourable condition. Due to the soft nature of the sediment these sites are likely to degrade even further in the future.

Type/Reference Sections:

There are no type or reference sections for the group or its formations in the Cotswolds.

Lithology:

Grey mudstone, thin bands of cementstone nodules/ concretions and calcareous siltstones.

Thickness: Variable, up to 23m in the Cirencester district.

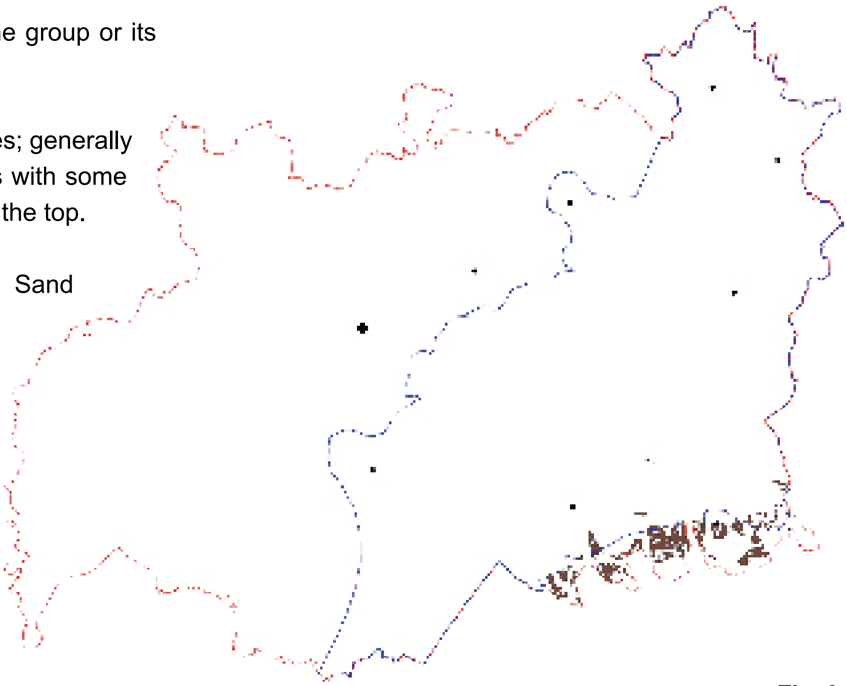


Fig. 3.25
Outcrop of the Ancholme Group (Kellaways ans Oxford Clay Formations combined)

e. **Late Jurassic to Quaternary**

Following deposition of the Oxford Clay Formation, marine conditions continued through the late Jurassic, depositing mudstones, sandstones and limestones. There are no traces of these deposits remaining in the Cotswolds area, but they are seen preserved to the south east of the country. Towards the end of the Jurassic period. The uplift affecting much of north-west Europe led to a fall in relative sea level, so by the Cretaceous period most of England, Wales and the Cotswolds formed part of an extensive landmass. A major marine transgression (the Cretaceous Chalk Sea), towards the Mid-Cretaceous re-submerged the Cotswolds region. Alpine mountain building at the end of the Cretaceous period caused major compression of north-west Europe, again leading to uplift. With the corresponding fall in global sea levels, the Cotswolds and surrounding regions once again became emergent, and have been so ever since. It was this uplift that gave the Cotswolds its slight south-easterly dip. Subaerial erosion through the Palaeogene and Neogene removed most of the Upper Jurassic, all of the Createaceous and younger strata from the region. The drainage pattern now seen was probably caused by this uplift. It has since been modified by later Quaternary processes.

Huntsmans Quarry, near Naunton:
A section through the base of the Great Oolite
(Eyford Member & Fuller's Earth Clay overlying Chipping Norton Limestone)

Geomorphology is the study of landforms, including their origin and evolution and the processes that shape them. Landforms provide clear evidence of the processes of erosion and deposition that have shaped the land. The character and form of the present day morphology of the Cotswolds is believed to have developed during the Tertiary period. It was however, predominantly during the Quaternary period (Pleistocene and Holocene) in which major modifications occurred that have been responsible for the evolution of the morphology of the Cotswolds as seen today. Many of the Geomorphological processes that sculpted the landscape are still active today, although on a much smaller scale. The landforms obviously closely reflect the underlying geology and geological structure within the area.

Towards the end of the Jurassic period, tectonic uplift affecting much of north-west Europe led to a fall in relative sea level. In response to this, by the early Cretaceous period (c.140Ma) much of England, Wales and the Cotswolds had formed part of an extensive landmass. Towards the mid-Cretaceous (c.120Ma) and onwards, a major transgression once again submerged the region. It was not until the Palaeogene (c.65Ma), when uplift resulting from major mountain-building events (Alpine Orogeny) in north-west Europe and a fall in sea level, lead to much of England and the Cotswolds becoming emergent once more, where they have remained since. In the Cotswolds, it is uncertain how much sediment had been deposited from the Upper Jurassic and Cretaceous periods onwards, as no deposits from this time remain. This was due to prolonged episodes of subaerial erosion during the Palaeogene and Neogene, removing possibly several hundred metres of sediment. It is believed that the uplift initiated during the Palaeocene was responsible for the formation of the escarpment and subsequent dip slope and the drainage pattern now seen within the Cotswolds, although the Proto Thames-Evenlode system was likely to have had a far larger catchment than it does now and included parts of Wales and the Midlands.

The effects of uplift, weathering and erosion on the rock sequence and structure determined the landform of the Cotswolds. The tectonic uplift that affected the region did so reactivating the ancient north-south trending deep basement faults, with the movement on them passed up through the Jurassic rock succession forming lines of weakness, which were weathered and eroded at a more rapid rate than the surrounding rocks. This produced a series of north-south aligned valleys, such as those seen in the Winchcombe, Broadway and Stroud areas. In addition to the north-south trending valleys, springs forming streams and rivers flowing south-east down the dip slope formed long, wide valleys, where as those flowing north and west carved steeper and deeper channels back into the plateau, forming the characteristic 'combes' for which the Cotswolds are well known.

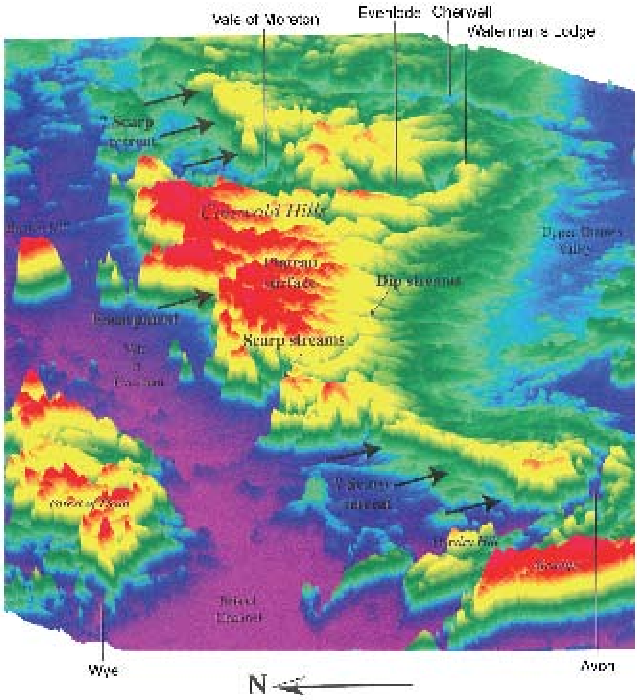


Fig. 3.26
Topography of the Cotswolds,
(Watts et. al., 2005)

All of the erosional processes taking place within the Cotswolds were greatly enhanced with the onset of the Quaternary period glacial and interglacial phases and it is predominantly this period that is responsible for shaping the landscape of the Cotswolds as it is today. As cold phases came to an end, huge amounts of melt water would have been released, dramatically modifying the existing valley systems, and depositing the Quaternary "drift" material as a series of river terraces and associated deposits. It is also believed that the valleys, combes and other associated erosional features of the Cotswolds were also affected by a particularly wet climate at the end of the ice age, further modifying the valley systems through erosional and depositional processes. Many of these valleys are now dry, or occupied by smaller 'misfit' streams. In addition to the fluvo-glacial features and deposits, there are also a number of mass movement and superficial structures associated with the geomorphology and landforms of the Cotswolds, such as landslides, solifluction spreads, cambering and valley bulging. Details of these features can be seen in sections 3.01.d, Superficial Structure.

Audit

Site surveying work undertaken by GGT in the past has concentrated on geological sites and exposures and recording 'solid geology' rather than on landforms and geomorphological features. As a result of this, records held by GGT relating to geomorphological sites and landforms are limited. There are however, references to many such features in numerous publications.

Many of the SSSI, GCR and RIGS sites within the Cotswolds covered within the geological audit also have a geomorphological element to them, especially those in close proximity to the escarpment where these sites are generally seen to exhibit varying degrees of camber and slippage. The superficial structures such as cambering, valley bulging landslips and the mass movement features could also be classed as geomorphological features/landforms but are dealt with in this document as geological features due to their association with the underlying structure of the Cotswolds.

Solifluction (soil creep) producing linear patterns on the side of Selsley Common.

Three principal landscape character types may be identified within the Cotswold AONB: the Escarpment; the Escarpment Valleys and Outliers; and the High Wold and Dip-Slope (Cotswold AONB 2004).

The landforms within the Cotswolds are predominantly the result of processes that operated during the Quaternary period and can generally be classified as post-glacial landforms. Within these landscape types are a series of characteristic landforms and features.

a. Escarpment

The morphology of the escarpment is the result of the regional dip of the strata (0.5° to 1.5° south or south-east). The Lias Group, capped by the Inferior Oolite and Great Oolite groups rise sharply from the low-lying Severn Vale forming a prominent, elevated west facing concave scarp slope, running virtually unbroken for almost 52 miles. At the base of the escarpment, the Lias Group clays, mudstones, silts and sandstones are exposed, Their soft and easily eroded nature has in many places resulted in slumping and erosion forming uneven and hummocky ground, stream valleys, gullies and bays towards the foot of the escarpment. Within the Lias Group the Marlstone Rock Formation, in numerous sections along the escarpment, forms distinctive terraces and secondary escarpments or a ledge below the main scarp. This is well demonstrated between Wotton-under-Edge to Dursley and Cheltenham to Chipping Campden. The formation also indicates the presence of a spring-line, occurring at its boundary with the underlying Dryham Formation, forming steep, narrow anti-dip streams flowing westwards into the Severn Vale below. The Lias rocks are in turn overlain by the limestones of the Inferior Oolite Group, which make up the main scarp-forming rocks in the north, reaching its highest elevation of 330m above sea level at Cleeve Hill. Passing south they begin to thin out and are replaced by limestones of the Great Oolite Group. The upper slopes of the escarpment are steeper than the lower slopes and in places have been dissected by embayments and combes. Breaches also occur where rivers have incised substantial valleys through the escarpment, such as the River Frome flowing out through the Stroud Valley.

b. Escarpment Valleys and Outliers

The escarpment has been progressively eroded south-eastwards over time, predominantly during the Quaternary period as a result of periglacial and fluvo-glacial processes. This progressive retreat through erosion has followed lines of weakness within the rocks and has resulted in the formation deep, wide valleys and combes, as seen in the Stroud (Golden Valley), Cheltenham (Chelt Valley) and the Winchcombe (Vale of Winchcombe) areas. In addition to this it has formed distinctive hills called outliers that are now detached from the main escarpment and rise up above the surrounding vale. Off the main escarpment there is a series of these outliers, marking the former position of the escarpment. The outliers are not included in the LGAP, as they are essentially now in the Severn Vale and not within the Cotswolds LGAP boundary. They are however, of particular geological interest as they expose excellent sections of the Lias Group, seen in the lower parts of the escarpment, that are often obscured by slipped and slumped material from the main escarpment. The best examples of these outliers can be seen at Robinswood Hill, Bredon Hill, Meon Hill, Oxenton Hill and Dumbleton Hill.

Coombe Valley and Wimley Hill

c. High Wold and Dip-Slope

As the escarpment rises from the Severn Vale to the west, the landscape forms the High Wold, a broad, elevated, gently undulating plateau area that gently dips to the southeast as it passes onto the High Wold Dip-Slope. The High Wold is underlain by limestones predominantly of the Inferior Oolite Group. It is characterised by an extensive upland plateau with a level or gently undulating landscape that has been deeply dissected by numerous streams. These have produced a network of convex interlocking hills and dry valleys, forming the upper reaches of larger river valley systems flowing in a general south easterly direction over the dip-slope and dip-slope lowland.

The principal area of High Wold is the Cotswolds High Wold Plateau, situated in the north Cotswolds; to the north of Stroud, north-eastwards to Chipping Campden and west of Bourton-on-the-Hill. There are also a number of other areas of High Wold which are physically separate from the main area, including the Nympsfield and Kingscote Plateau, Minchinhampton Common, the Bisley Plateau and the Rissington Plateau and Milton Downs. These have become separated by deeply dissected valleys (High Wold Valleys), which are predominantly dry or ephemeral flow headwater valleys which generally posses a broad valley form and shallow slope profile.

On the High Wold a series of rivers rise at spring lines and flow across the plateau. They share a common source for their headwaters but belong to two different catchments; the Thames and the Severn. The valley alignments therefore display a radial progression from the south-east flowing towards the Thames, through to the south, south-west and westwards towards the Severn. The Thames tributaries include the Rivers Churn, Coln, Leach and Windrush (and its tributary, the Dickler), flowing through north-west south-east aligned valleys. To the west of the Thames tributaries, a series of south and southwesterly tributaries flow into the River Frome and then into the Severn; these include the south-west aligned Painswick and Slad valleys systems. In the north Cotswolds the River Chelt drains the southern part of the Cleeve Hill Plateau and vale on the western side of the escarpment. The River Isbourne is unusual as it flows northwards, draining the Vale of Winchcombe at the north facing scarp of the main hill mass of the north Cotswolds.

The river valleys tend to share a similar form; an incised valley with steep, convoluted sides and a gentle convex profile with the High Wold junction. The valley sides are often dissected by secondary valleys, often dry, linking to the main river. The High Wold Valleys predominantly rise on the limestones of the Inferior Oolite Group and the rivers cut down through the strata, exposing the rocks of the older Lias Group. The characteristic valley morphology seen today is attributed to a considerable increase in river discharge from glacial melt water streams. Many of the river valleys demonstrate valley meanders, pronounced meanders with distinctive interlocking spurs. The meanders have a greater wavelength and are disproportionate to the size of the contemporary rivers and streams now flowing through them.

The High Wold Dip-Slope landscape is characterised by an undulating and rolling landform, generally dipping away from the High Wold in a south-easterly direction. It borders and is transitional between the High Wold to the east and Dip Slope Lowland to the south east. As a result of this, its drainage pattern is a continuation of the High Wold, dissected by a number of rivers such as the Coln, Leach and Windrush. These rivers posses a much broader valley form than those on the High Wold and common also are smaller, narrow valleys with convex slopes, which are often dry valleys. Passing south-east from the High Wold Dip-Slope onto the Dip-Slope Lowland sees a change in landscape to an area of gentle undulating lowland, underlain by limestones of the Great Oolite Group. There are few tributary streams in this area, it is almost a continuous tract of land, only broken by the valleys of the Churn and Coln. Where they do occur, their small valleys tend to follow the same slope and dip orientation as the underlying strata.

Dry Valley near Tresham

The Cotswolds rivers and valleys have attracted wide attention for over 150 years. The present day valley systems are considered remarkable for their size compared with the volume of their streams. The form of the Cotswolds escarpment and its valleys was given classic status by W.M. Davis (1899, 1909) and the area has since been studied by numerous workers (Buckman, 1899, 1900; Arkell, 1947 a & b; Beckinsdale and Smith, 1955; Dury, 1955; Beckinsdale, 1954, 1970). They have mostly concentrated on the drainage of the area, especially the deep incised valleys.

a. Dry Valleys and Misfit Streams

The underfit streams occupy the main valleys flanked by dry valleys that were eroded originally by a stream or river that no longer has a channel bed, are often tributaries of the associated misfit streams and can form through a number of different mechanisms. Many of the dry valleys can be seen hanging 5-6m above the level of the present day stream valley floor and misfit streams are much smaller than the valleys through which they flow. The fluvial processes in operation at present are inadequate to account for their form and the extent of the misfit streams and dry valleys associated with them and so must be attributed to a wetter past climate. They are a common feature of the Cotswolds and are associated with most of the areas major streams and rivers.

Table 3.1
Dry Valleys and Misfit Streams

Location	Dry Valley	Misfit Stream
Postlip Valley	x	
Severn Springs (two dry valleys converge)	x	
River Windrush	x	x
River Eye	x	
Sherborne Brook	x	
River Churn	x	x
River Coln	x	x
Ampney Brook	x	
Shill Brook	x	

b. Valley Meanders and Abandoned Meanders

Valley meanders and to a lesser extent abandoned meanders are well developed in the Cotswold river valleys and the majority are occupied by modern smaller misfit streams. A number of rivers also have abandoned meanders, their course has been shortened by cutting across the neck of the meander loop. A good example of this can be seen in the valley of the River Windrush to the south of Bourton-on-the-Water. Meanders and abandoned meanders are developed along much of the courses of the principal rivers.

Table 3.2
Valley Meanders and Abandoned Meanders

Valley / River	Valley Meanders	Abandoned Meander
Windrush	x	x
Leach	x	
Evenlode	x	x
Coln	x	x
Cam	x	
Shill Brook		x

c. Wind Gaps

Wind gaps are relatively scarce in the Cotswolds. They are found at the heads of four of the Cotswolds main rivers; the Windrush, Coln, Churn and Frome. They mark through valleys that were originally occupied by sizable streams which have been beheaded by subsequent streams developed ahead of the escarpment. They are now dry in their uppermost sections and often contain small misfit streams in their lower courses.

Table 3.3
Wind Gaps

Location	Source
Oat Hill	At head of Windrush Valley
Stumps Cross	Windrush Valley
Lyne's Barn Farm	At head of tributary valley of the Windrush
Charlton Abbots	At head of Coln Valley
Andoversford	At head of tributary valley of the Coln
Severn Springs	At head of Churn Valley
Sapperton	Between the Frome and Thameshead
Charlton Kings	At head of tributary valley of the Chelt

3.07 Karstic Forms

The Cotswolds is not a region well known for its development of karstic forms. Some karstic features can be found, especially the fluvio-karst forms of dry valleys (see above) and sink holes. Many of the dip-slope streams of the Cotswolds have discontinuous drainage with underground courses, for example, the Leach, Shill Brook and Ampney Brook (Gouldie *et al*., 1980). Arkell (1947) and Richardson *et al* (1946) refer to 'swilly holes' (swallow holes) at numerous locations within the Cotswolds.

Table 3.4
Karstic Forms

Location	Sink Hole	Underground Channel	Developed on
Waterman's Lodge	x		Base of Forest Marble Fm.
Coombe & Ramsden Heath	x		Oxford Clay Fm.
Severn Springs (New Farm)	x		Fullers' Earth Fm.
Cleeve Hill	x	x	Inferior Oolite Gp.
Stanway		x	Inferior Oolite Gp.
Withington	x		Inferior Oolite Gp.
Sturt Farm (3 locations)	x(3)		
Shill Brook Valley	x		
Blockley	x(2)		Inferior Oolite Gp.

Summary

The Cotswolds are a classic escarpment/dip-slope terrain, developed on the gently dipping Jurassic strata. The outstanding natural beauty and scenic geodiversity of the Cotswolds is the result of the underlying structure, the juxtaposition of the different rock types, their variations in permeability and the geological and geomorphological process that have acted on them. All these factors account for the form of the escarpment, plateau, valleys and lowlands, the drainage patterns and the nature and location of mass movement features.

APPENDICES TO SECTION 3

GEODIVERSITY AUDIT

APPENDIX 1: Site Stratigrphy

APPENDIX 2: Site Inventory

Appendix 2: SITE INVENTORY

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Alderton Hill Quarry	SP 006 345	SSSI GCR	LIAS GROUP Whitby Mudstone Fm.	A site long famous for its well preserved Lower Jurassic insect fauna. Fossil insects recovered from nodules in the Lower Toarcian "Fish Bed" have been described in several publications and include type specimens of Mesozoic dragonflies and Gomphites as well as the remains of a large cockroach. Other remains found include fish, Ichthyosaur bones, well preserved cephalopods and the holotype of the crustacean *Eryon richardsoni*. The site is a key palaeoentomological locality, in particular for understanding the anatomy and evolution of early insect fauna.
Aston Farm Cutting	SP 146 213	RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Aston Limestone Fm. *(Notgrove Mb., Gryphite Grit Mb.)* Birdlip Limestone Fm. *(Harford Mb., Scottsquar Mb.)*	This site is on the disused Andoversford to Bourton-on-the-Water railway line, to the south-east of the Harford Railway Cutting SSSI/GCR site. It exposes an excellent section through the middle and upper parts of the Inferior Oolite Group, from the upper part of the Birdlip Limestone Formation, to the middle part of the Salperton Limestone Formation, a similar sequence to that exposed at the Harford Cutting. Exposed are good examples of erosional breaks/discontinuities, facies variations, faulting (reverse and normal), conglomerates, biogenic activity and fossil assemblages. Reference section for the Harford Member, Aston Limestone Formation, Lower Trigonia Grit Member and the Gryphite Grit Member.
Aston Magna Quarry	SP 198 356	RIGS	Tufa LIAS GROUP Dyrham Fm. Charmouth Mudstone Fm.	Former brick pit exposing Charmouth and Dyrham Mudstone Formations. The junction between the two is indicated by a spring on the west side of the site which deposits tufa in small streams. Exposures are mostly obscured.
Avon Ford Cutting	ST 909 902	RIGS	GREAT OOLITE GROUP Cornbrash Fm.	A small, mostly overgrown cutting exposing one of the few sites in the Great Oolite Group, Cornbrash Formation in Gloucestershire. It lies near the NW limit of the Cornbrash, towards its shoreline when deposited. Excavation should expose the underlying Forest Marble Formation and overlying Kellaways Formation (Kellaways Clay Member), making the site of considerable geological value. The sequence is of limestones with marls, the Lower Cornbrash (marl, biomicrite) is in the *Clydoniceras Discus* Zone and is highly fossiliferous, the Upper Cornbrash (sandy clay, biosparite) is in the *Herveyi* Zone, brachiopods and bivalves are common.
Balls Green Quarry & Mine	SO 865 995	RIGS	GREAT OOLITE GROUP White Limestone Fm. INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Birdlip limestone Fm. *(Scottsquar Mb., Cleeve Cloud Mb.)*	A large surface and underground quarry exposing Aalenian and Bajocian limestones. Virtually all of the members are accessible in different parts of the quarry and demonstrate the typical features of those units, including fossils. The underground quarry is the largest of many in the area and displays excellent industrial archaeological remains as well as geology in 3-D. There is an unusual breccia/conglomerate development at the base of the Upper Trigonia Grit Member and unconformable contact, a bored and eroded surface, with the underlying Scottsquar Member (Oolite Marl). The contact between the Oolite Marl and the underlying Lower Freestone, again indicates a minor unconformity, with a planed, bored surface. Varying lithologies are shown; oosparites, oomicrites, pelmicrites, biosparites, marls and marly partings. Structure shows virtually horizontal bedding, little evidence of gulling but some widening of E-W trending joints and minor vertical displacement on some of the jointing. Sedimentary structures are not easily visible due to extensive drip-stone coatings. Palaeontology is limited in the Aalenian rocks, containing shell fragments of *Plectothyris and Globirhynchia*. The Bajocian sequence demonstrates a more diverse fauna, including; *Trigonia, Pleuromya, Modiulus, Stroudithyris, Lobothyris* and *Stiphrothyris.*

SITE NAME	GRID REF’	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Bourton on the Hill Quarry	SP 169 327	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm *(Cleeve Cloud Mb.)*	Exposed here is the Cleeve Cloud member of the Birdlip Limestone Formation. The 10-12 m sequence exposed can be referred to as the Lower Freestone but the lowest part does bear comparisons with the ‘Guiting Stone’ of Jackdaw Quarry. The lower beds are variously sandy with ferruginous oolites and some shell fragments, succeeded by trough cross-bedded oolites. A limited fauna includes oyster fragments and poorly preserved brachiopods. The sequence appears horizontally bedded; the lowest unit appearing as large, jointed blocks. A minor but clear normal fault downthrowing to the NNW occurs in the southern face, evidence of cambering.
Breakheart Hill Quarry	ST 755 968	RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb., Cleeve Cloud Mb., Crickley Mb.)*	A very valuable exposure of Inferior Oolite and post ice-age disruption features on the escarpment of the south Cotswolds. The design of the quarry (shallow lifts and wide benches) provides extensive bedding plane and hardground exposures probably unequalled elsewhere in the Cotswolds. The strata provide instructive comparisons with more developed, thicker sequences in the Cotswolds, such as at Leckhampton Hill. Limestone lithologies vary; predominantly oosparites, with granule/cobble intraclasts, the grit (Clypeus, Upper Trigonia) lithologies are mainly biosparites, the Clypeus Grit contains abundant ferrginous peloids. Vein quartz pebbles occur towards top of Scottsquar Member along with some tufa, dripstone deposits and minor clay/marl seams. Abundant brachiopods, bivalves and serpulids in Upper Trigonia Grit. Hardgrounds within and at the top of the lower members and at the top of the Upper Trigonia and Clypeus grits plus echinoids and rare ammonite fragments. Most of these hardgrounds are bored and oyster-encrusted. Bedding appears near horizontal though locally disrupted by minor normal faulting (displacement 1-2m). Extensive post-glacial fissuring and cambering is evident downslope.
Broadway Quarry	ST 7490 9790	RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Birdlip Limestone Fm *(Cleeve Cloud Mb., Crickley Mb.)*	This is the most widely known of all the Stinchcombe Hill quarries. Exposed is almost the full extent of the Inferior Oolite Group on the hill in two very accessible faces. The quarry is cut at two levels: the lower level exposes the Cleeve Cloud and Crickley members, the upper level exposes the upper part of the Cleeve Cloud Member and its unconformable contact with the overlying Upper Trigonia and Clypeus Grit Members. The lithologies vary including oosparite, bioclastic, detrital and peloidal limestones and oolitic marls. The whole section is highly fossiliferous, with many good sedimentary structures. Also well displayed are numerous hardgrounds, cambering and gulling.
Brownstones Quarry & Track	SO 951 182	RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Upper Trigonia Grit Mb.)* Aston Limestone Fm. *(Notgrove Mb., Gryphite Mb.)*	Within Leckhampton Hill SSSI, the trackway cutting exhibits excellent exposures of the upper beds of the Inferior Oolite Group and one of the best and laterally continuous outcrops of the Upper Trigonia Grit Member. On the hill, this is the only location with good access to the Gryphite and Notgrove Members. Here the Notgrove Member is condensed, with erosional surfaces (unconformities) at its base and upper surface, the latter a bored and oyster encrusted hardground. Fossils are abundant, from the Gryphite Grit Member, *Gryphaea bilobata* and *Pecten* sp. especially common; from the Notgrove Member; *Ostrea* sp.; and *Trigonia* sp. from the Trigonia Grit member.

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Bull Cross, The Frith and Juniper Hill	SO 868 082	SSSI GCR	INFERIOR OOLITE GROUP Aston Limestone Fm. *(Gryphite Grit Mb., Lower Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb., Cleeve Cloud Mb.)*	Bull Cross, The Frith and Juniper Hill joint biological and geological SSSI contains a number of disused quarries, of which The Frith has been designated a geological SSSI and is also a GCR site. The section exposed here was first described by Buckman in 1895 and contains a sequence of Inferior Oolite Group rocks (Birdlip and Aston Limestone Formations) in the axial region of the Painswick syncline. At the base of the section is the Cleeve Cloud Member (Lower Freestone), a shelly, oobiosparite, limonite-stained, with planed and bored hardground developed at the top. The succeeding Scottsquar Member (Oolite Marl / Upper Freestone) is one of the best exposures of this unit in the Cotswolds and is comprised entirely of the Oolite Marl facies. Baker (1981) records an irregular scour or possible karstic surface 3.2 m above its base. This member is highly fossiliferous at some levels, yielding some of the few zonally significant ammonites known from this level. The member is also particularly rich in brachiopods. The top of the Scottsquar Member is a planed and bored hardground, representing the Aalenian denundation of Buckman (1901) and here the surface is highly irregular and appears to extend down in crevices in the underlying bed. The overlying Lower Trigonia Grit has yielded a large number of well-preserved ammonites; first described by Witchell (1882a), his extensive collection, now in the Natural History Museum, make up one of the most extensive faunas from the Lower Bajocian Discites Zone in England. The succeeding Gryphite Grit Member comprises sandy bioclastic limestones, commonly containing *Gryphaea bilobata*.
Campden Tunnel Pit	SP 161 408	SSSI GCR	Wolstan Fm.: *(Paxford Gravel Mb.)*	The pit exposes a mixture of Pleistocene sands, gravels and silts, interpreted as glacial sediments infilling a deep glacial over-flow channel through which melt water is believed to have run from the ice-filled valley of the River Avon to the north and west into the drainage system of the River Evenlode to the south east. These deposits are likely to prove a vital connection between the sequence of glacial deposits in the Midlands and those of the Upper Thames terraces in the Evenlode Valley.
Catbrain Quarry	SO 868 117	RIGS	INFERIOR OOLITE GROUP Aston Limestone Fm. *(Gryphite Grit Mb., Lower Trigonia Grit Mb.)* Birdlip Limestone Fm *(Scottsquar Mb.)*	This site displays the best exposure of Middle Inferior Oolite in the Painswick syncline area. The quarry is of great interest for its palaeontological, stratigraphical and sedimentological features. Parts of the faces are now obscured by scrub/vegetation but access is still relatively easy. Exposed are: the Scottsquar Member (Upper Freestone Oolite Marl), Lower Trigonia Grit Member and the Gryphite Grit Member. Lithologies are essentially biosparites, sands, oolites, marls, limonites and intraformational conglomerates. Structurally the section shows gulling, cambering and minor faulting. A limited fauna recorded, comprising bivalves, brachiopods, gastropods and corals.
Charlton Kings Quarry	SO 955 186	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Scottsquar Mb. Cleeve Cloud Mb.)*	Within Leckhampton Hill SSSI, this site poorly exposes the Cleeve Cloud Member and Scottsquar Member (Lower Freestone, Oolite Marl and Upper Freestone) The limited outcrops show excellent cambering structure and rotational fault movement, the ground towards the base of the quarry is hummocky due to natural slumping and man-made spoil piles. Where exposed, two lithologies are recognised, a fine-medium grained oolite and a shell-detrital oolite.

SITE NAME	GRID REF’	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Chedworth Railway Cutting	SP 047 144 to 053 130	RIGS	Tufa GREAT OOLITE GROUP Fuller’s Earth Fm. Chipping Norton Limestone Fm. INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Aston limestone Fm. *(Notgrove Mb., Gryphite Grit Mb., Lower Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Harford Mb. Scottsquar Mb.)*	A series of outcrops along a section of the old disused Midland and South Western junction railway line from Cheltenham to Cirencester. The site has been a nature reserve since it was bought by GWT in 1969. Exposed here is an excellent suite of rocks from the Inferior Oolite Group and Great Oolite Group, first described by Buckman (1890, 1892). Exposed are excellent sections through the Inferior Oolite Group, capped by the Great Oolite Group, yielding a wide fossil assemblage and demonstrating good sedimentary structures, a number of normal faults and five important non-sequences. The site is a reference section for the Upper Trigonia Grit and Clypeus Grit members and the Hampen Formation. Commonly found within the Clypeus Grit Member is the echinoid *Clypeus ploti*, “the Chedworth Bun.”
Chedworth Railway Cutting (South Villa Cutting)	SP 052 133	RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Aston Limestone Fm. *(Notgrove Mb.)*	An outcrop within the Chedworth Railway Cutting, both the east and west cuttings expose the junction (non-sequence) between the Aston and Salperton Limestone Formations (Notgrove Member and Upper Trigonia Grit Member). This junction is represented by a bored and oyster-encrusted hardground. Fossils are abundant in the scree and in the Upper Trigonia Grit (bivalves, brachiopods, ammonites), few fossils within the Notgrove Member, except on the hardground.
Chedworth Railway Cutting (Tufa Site)	SP 054 129	RIGS	Tufa INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Upper Trigonia Grit Mb)*	An interesting site demonstrating active tufa deposition within the Chedworth Railway Cutting. A spring rises from the eastern embankment in an outcrop of the Upper Trigonia Grit. The spring appears to rise in an old tufa-encrusted cast iron trough and runs down the rock outcrop and across the old railway track, forming a tufa apron approximately 4 m wide by 4 m high. Encased within the tufa are limestone gravel, wood, leaf, moss and farm debris. It is possible that the spring was active during the Roman occupation of the Chedworth Roman Villa near by.

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Cleeve Common	SO 985 255	SSSI	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Aston Limestone Fm. *(Rolling Bank Mb., Notgrove Mb., Gryphite Grit Mb.)* Birdlip Limestone Fm. *(Harford Mb., Scottsquar Mb.,* *Cleeve Cloud Mb., Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm. Whitby Mudstone Fm.	Cleeve Hill represents the most complete development of Inferior Oolite Group in the country, attaining a thickness of approximately 100m. The sequence exposed on the common extends from the Lias Group (Whitby Mudstone Formation) through to the top of the Inferior Oolite group. The common has been designated SSSI status based on its outstanding geological and geomorphological interest as well as its biological importance. Within the SSSI boundary are numerous quarries and pits, designated as regionally important geological sites (RIGS). The geological importance of the common is as follows: Cleeve Common lies on the axis of the thickest sequence of Inferior Oolite in the country. It is the only area in the Cotswolds where the full sequence can be seen (including the Rolling Bank Member). The valley of Postlip Warren shows the best example of "ridge-and-trough" features in Great Britain. A wide range of structural features are displayed, including unconformities and hardgrounds, faults, cambering, gulling and numerous sedimentary structures. A diverse range of fauna can be found on the hill. In addition to the SSSI importance of the common, the additional RIGS sites further enhance the geological importance, diversity and potential for study on the hill. Type section for the Rolling Bank Member and reference section for the Crickley, Cleeve Cloud, Upper Trigonia Grit and Clypeus Grit members.
Coaley Peak	SO 794 008	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Cleeve Cloud Mb., Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm.	A G.W.T reserve located on the edge of the scarp,. The near complete Inferior Oolite Group sequence illustrates many of the key features of carbonate sedimentation. Contains the probable Pea Grit equivalent of Richardson (1910). It is also the type locality for Mudge's "Frocester Hill Oolite"). Shows excellent cross-bedded oolites and conglomeratic pebble beds and erosional hardgrounds. Good Scissum and Cephalopod beds outcrops, yielding belemnites and ammonites. Prominent WNW-ESE normal fault, with c.1 m throw, also a few small displaced joints and gulls. Excellent panoramic view across the River Severn and Severn Vale.
Coaley Wood Quarries	ST 786 996	SSSI GCR	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Upper Trigonia Grit Mb.)* Birdlip limestone Fm. *(Cleeve Cloud Mb., Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm.	This site exposes a good sequence form the Bridport Sand Formation to the Salperton Limestone Formation (Aston Limestone Formation missing). A long famous geological site for the abundant Lower Jurassic fossils found in the Cephalopod Bed and Cotteswold Sands Formation (Bridport Sand Formation). Several particular horizons are especially noted for their ammonite fauna (*striatulum* and *variabilis* subzones), the latter containing, within a thin isolated sandstone layer, a rare ammonite, *Haugia*. Well developed cross-bedding and gulling apparent. The site is very useful to demonstrate the succession along the escarpment and the horizontal facies change with the Bajocian over-step.

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Conygre Quarry	SO 047 867	RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Upper Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb., Crickley Mb.)*	Two disused quarries showing fair exposures of the Birdlip Limestone Formation (lower quarry) and Salperton Limestone Formation (upper quarry). Both quarries are within woodland with good accessible exposures, although the upper quarry is badly degraded due to scree build-up. Good sedimentary structures can be seen throughout the sequence, the Upper Trigonia Grit Member is especially fossiliferous.
Coppice Limestone Type Section	ST 808 905	RIGS	GREAT OOLITE GROUP Coppice Limestone Fm.	This site is the type section for the Coppice Limestone Formation, within the Upper Bathonian Great Oolite Group. The quarry is now in-filled and almost entirely overgrown and wooded. A few blocks exhibiting the classic porcellaneous micritic limestone lithology can be seen in a poor exposure on the SW edge of the quarry. Within this also can be seen some fine veins of sparry calcite. Cave *et al* (1977) observed at this site; Athelstan Oolite, and Coppice Limestone capped by Forest Marble. This sequence is no longer visible.
Cotswold Hills Quarry (Three Gates Quarry)	SP 081 292	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Harford Mb., Scottsquar Mb., Cleeve Cloud Mb.)*	An almost complete, continuous exposure of the Lower Inferior Oolite (Birdlip Limestone Formation), from the middle part of the Yellow Guiting Stone to the Harford Sands (Cleeve Cloud Member to Harford Member). The principle value of this site lies in good exposures of large-scale sedimentary structures; important, though currently poor exposures of highly fossiliferous Oolite Marl in coral-prone facies; and a rare and important exposure of the contact between the Yellow Guiting stone and the overlying White Guiting Stone. This boundary probably correlates with the top of the Sandy Beds (i.e. the base of the Bryozoan Beds and the Crickley Coral Bed) in the western part of the basin and is of fundamental importance in understanding the large-scale sequence stratigraphic architecture of the Birdlip Limestone Formation. The only other locality where this contact is currently exposed in the eastern part of the basin is at Guiting Quarry, 1 km to the NNW. Lithologies vary; Yellow Guiting Stone: sandy oolitic and bioclastic limestones, with oyster-encrusted hardground at top, bryozoa, strongly ribbed and smooth oysters, echinoids and brachiopods. White Guiting Stone: cross-bedded oolite, oyster-encrusted hardground. Oolite Marl: marls, bioclastic limestone, peloidal limestone, fossil horizon; corals, pelecypods and brachiopods, hardground in middle part. Harford Sands: sands and clays. The site is also reference section for the Cleeve Cloud, Scottsquar and Harford members.
Crickley Hill	SO 929 161	SSSI GCR	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Cleeve Cloud Mb., Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm. Whitby Mudstone Fm.	Crickley Hill, on the Cotswold escarpment exposes one of the best sections of the lower part of the Birdlip Limestone Formation in the Cotswolds. It is one of the few localities where the base of this formation has been exposed. It has attracted the attention of geologists since the earliest days of the science due to its fine development of the famous Pea Grit (Crickley Member). The escarpment here provides the finest and thickest outcrop of Pea grit in the region and it is the type section for this member. Within the Crickley Hill Country Park are a number of small disused quarries, exposing various members of the Birdlip Limestone Formation, but it is the outcrops on the escarpment that are of interest and importance. Exposed is the blue/grey clay of the Whitby Mudstone Formation (Lias Group) found towards the base of the sequence, overlain by the Cotteswold Sands (Bridport Sand Formation), which contain doggers towards the top in the Leckhampton Member (Scissum Beds), the Lower Limestone and Pea Grit (Crickley Member) and the Lower Freestone (Cleeve Cloud Member). Type section for the Crickley Member, reference section for the Cleeve Cloud Member.
Cutsdean Quarry	SP 105 314	RIGS	GREAT OOLITE GROUP Chipping Norton Limestone Fm.	This site is a former shallow quarry and now a GWT nature reserve. Exposed is a sequence of the Great Oolite Group Chipping Norton Limestone Formation, approximately 3 m in depth. The lower 1.5 m section displays fine-grained, massive beds, cross-bedded and jointed; the upper beds (tilestones) appear more coarse-grained and more fissile and flaggy. A limited fauna observed, predominantly of small oyster shell fragments.

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Daglingworth Quarry	SP 001061	RIGS	GREAT OOLITE GROUP Forest Marble Fm. White Limestone Fm.: *(Ardley Mb., Shipton Mb.)* Hampen Fm. Taynton Limestone Fm.	A large working quarry, exposing one of the most complete sections through the Great Oolite Group. The Througham Member of the Fuller's Earth Formation forms the quarry floor (max. depth 6 m from core data), exposed is c.0.6 m of the Taynton Limestone Formation, coarsely ooidal limestone, overlain by c.6.74 m of the rarely exposed Hampen Formation, a fine to very fine-grained oolite, containing rare carbonaceous plant fragments, interbedded with marl bands containing common bivalves and oysters. This is overlain by c.20 m of the White Limestone Formation; the lower c.10 m of the Shipton Member, a peloidal limestone, including the Excavata and Roach beds at the top, passing into (with no hardground development) the Ardley Member. The Ardley Member here is c.10 m thick and an almost complete section, its base demonstrates herringbone cross-bedding and middle section contains several beds of the 'Dagham Stone'. The member is capped by a well-developed bored and oyster-encrusted hardground, overlain by the Forest marble Formation.
Daylesford Quarry	SP 254 271	RIGS	GREAT OOLITE GROUP Chipping Norton Limestone Fm.	This site is close to the western limit of outcrop of the Chipping Norton Limestone Formation and is the lowest formation of the Great Oolite Group to extend across the Moreton Axis, apparently little effected by the thinning which characterise those beds underlying it. It is one of two sites that possibly expose this formation east of the Vale of Moreton. Lower beds are massive, sandy oolites, fine-grained, upper beds are a shelly oolite, more fissile with secondary calcite on bedding surfaces, and top 1m is flaggy.
Deadman's Quarry	SO 947 184	RIGS	INFERIOR OOLITE GROUP Aston Limestone Fm. *(Lower Trigonia Grit)* Birdlip limestone Fm *(Scottsquar Mb., Cleeve Cloud Mb.*	Within Leckhampton Hill SSSI, an excellent exposure of the Lower Freestone, Oolite Marl, Upper Freestone and Lower Trigonia Grit. The Lower Freestone shows excellent large-scale cross-bedding, a well developed bored and oyster-encrusted hardground and is separated from the Upper Freestone by a thin band of the Oolite Marl. Fossils are scarce in the freestones but the marl contains the brachiopod *Plectothyris fimbria*, various gastropods and sponge fragments. An unconformity separates the Upper Freestone from the Lower Trigonia Grit, which unlike the unfossiliferous oolitic freestones is very shelly and shell detrital. A normal E-W fault can be seen at the north end of the quarry, downthrowing the Upper Freestone and Oolite Marl approximately 13 m to the north, up against the Lower Freestone. Also visible are a number of major gulls, probably formed as a result of cambering at the escarpment and pressure release following quarrying.
Ditchford Hill Gravel Pit	SP 218 371	RIGS	Wolstan Fm.: *(Paxford Gravel Mb.)*	This site lies within the largest outcrop of the pre-glacial Paxford Gravel Member and is well exposed in this small quarry. Within the size range of the components, it is poorly sorted, indicating rapid deposition; available evidence suggests a northwards flow and thickening of the deposit in that direction. The clasts are almost entirely local limestones and the absence of northerly derived rocks is in contrast to glacial-derived material. Matrix-supported, medium gravel (2-50 mm), sand/silt fraction, in parts a limonitic-coloured appearance to the whole deposit. A dark brown boulder clay disrupting the bedding at the eastern end of the quarry is further evidence of the pre-glacial nature of these gravels.
Doverow Hill	SO 815 054	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm *(Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm.	The site exposes bioclastic rip up clast limestone from the shelly Scissum Beds and oolitic and sparitic limestone from the Lower Limestone (Birdlip Limestone Formation). Broken shells only, no complete macrofossils. The Cotteswold Sands (Bridport Sands) are indicated by rabbit and badger holes. Beds are dipping at 30° north, thus showing their faulted/slipped relationship with the main Cotswold scarp. A major SE-NW trending fault has lead this section to rotate and slip down by approximately 250m, displacing the section and stratigraphy by approximately 50m. Possibly one of the largest landslips in the county.

SITE NAME	GRID REF’	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Downskilling Quarry	ST 851 897	RIGS	GREAT OOLITE GROUP Forest Marble Fm. White Limestone Fm.	A partially in-filled and landscaped quarry, once exposing over 9 m of the Great Oolite Group, (White Limestone and Forest Marble Formations) including the Athelstan Oolite, Coppice Limestone and Forest Marble. It is poorly exposed and now only small, isolated sections remain between 0.5 m to 1 m high. Variable lithologies are present (Cave et al 1977): bioclastic, micritic, oolitic and sandy limestones, some limonite staining. Currently exposed section shows a sequence of shelly, oolitic limestone, possibly cross-bedded and thinner, flaggy units. In the cross-bedded, thicker units no fossils were observed; in the flaggy units a limited fauna of gastropods, shell fragments and echinoid spines were seen.
Easter Park Farm (Woodchester Park Farm)	SO 810 011	SSSI GCR	GREAT OOLITE GROUP Fuller’s Earth Fm. *(Dodington Ash Rock, Minchinhampton Beds)*	A site neglected for many years. Recent excavation revealed 4.5 m of the once exposed c.6 m of the Dodington Ash Rock, part of the Fuller’s Earth Formation (roughly comparable with the Shipton Member, White Limestone Formation in the North Cotswolds - both Morrisi Zone) overlying the upper part of the Minchinhampton Beds (roughly comparable to the Hampen Formation of the North Cotswolds - both Subcontractus Zone). The uppermost 1.5 m of the Minchinhampton Beds consists of a white-weathering porcellanous, micritic limestone with ferruginous grains and small marl-filled pockets on the top surface, overlain by the Dodington Ash Rock, with a persistent marl parting at its base, followed by massive to well-bedded and in part, cross-laminated ooidal limestones. The top surface is smoothed and pitted and succeeded by a semi-porcellanous, nodular, shelly, fine-grained limestone with a diverse fauna including; bivalves, brachiopods, echinoids, gastropods, corals and the ammonite *Morrisiceras* (*Morrisi* Zone). This ammonite fauna is rare within the Cotswolds and therefore of biostratigraphical importance for correlation of the Bathonian succession. This site exhibits one of the few good Dodington Ash Rock exposures and demonstrates the eastward transition from the fine-grained limestones of the south Cotswolds to the coarser ooidal limestones seen at Minchinhampton.
Eyford Hill Pits	SP 138 255	RIGS	GREAT OOLITE GROUP Fuller’s Earth Fm *(Eyford Mb.)*	A disused quarry exposing the Fuller’s Earth Formation and overlying Eyford Member. The majority of the exposure consists of thinly-bedded, flaggy calcareous sandstones with numerous burrows and borings. A thin (c.20 cm) clay horizon separates the sandstones in the lower part of the face and a thicker (c.30 cm) band of laminated soft sand appears roughly half way up the face. The flaggy beds above the soft sand grade upwards from calcareous sandstone to sandy limestone. The exposure is capped by a thinly bedded oolitic, sparry limestone. Fuller’s Earth Clay is mostly obscured, but underlies the Eyford Member. The site is useful in demonstrating the different facies within the Eyford Member and, according to Richardson (1929) also demonstrates the changes in facies from those exposed in Huntsman’s Quarry 1 km to the west.
Far End Cutting	SO 8968 1065	RIGS	Head Gravel	Excellent exposure of Pleistocene Head gravels, derived from local Middle Jurassic limestones upslope. A variety of gravels are present over partially exposed bedrock (breccia with sandy/earthy matrix, oolite sand with scattered angular rock fragments, earthy/sandy angular gravel mottled with lime cement, clean loose angular gravel, interstratified oolite sand and angular gravel streaked with lime cement). Field relation of gravels suggests a series of deposition / deep erosion / infill events, superimposed upon one another.
Farmington Quarry	SP 130 168	RIGS	GREAT OOLITE GROUP Hampen Fm. Taynton Limestone Fm.	A large working quarry, the longest established and most extensive remaining quarry working Cotswold stone. The site contains probably the most extensive sections of the Taynton Limestone Formation in the county. The formation has extensive outcrops in the Windrush Valley in the area around Farmington, Northleach and Taynton. At this site it demonstrates prominent cross-bedding (with cosets more than 5m thick) typical of the formation in this region with two interesting surfaces, one onto which these foresets downlap and an upper surface which sharply truncates the foresets. Also exposed is the overlying Hampen Formation. The site is the reference section for the Taynton Limestone Formation and the type area of Taynton is just across the county boundary in Oxfordshire. Sections here were first recorded by Richardson (1933) and more recently Sumbler (1995), Sumbler *et al* (2000).

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Fiddlers Elbow Quarry	SO 886 143	RIGS	GREAT OOLITE GROUP Fuller's Earth Fm. *(Upper Estuarine Clay)* Chipping Norton Limestone Fm. INFERIOR OOLITE GROUP Salperton limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Aston Limestone Formation *(Gryphite Mb., Lower Trigonia Grit Mb.)* Birdlip Limestone Fm *(Scottsquar Mb., Cleeve Cloud Mb., Crickley Mb.)*	A large, disused quarry on the scarp, showing a good section through the Inferior Oolite Group and base of the Great Oolite Group. According to Channon (1950) a typical "Painswick" section from the Pea Grit through the Coral Bed, Lower Freestone, Oolite Marl, the Lower Trigonia, Gryphite and Clypeus Grits, overlain by the Chipping Norton Limestone and Fuller's Earth. The strata is very loose and broken forming large screes. Lithologies vary, including oolites, sands, biomicrites, sparites, pisolites, shelly limestones and iron-shot marls. There is good cross-bedding and graded-bedding in some of the oolites. The quarry is noted for its structurally complex nature with steep dips of 20° to 60° to the N-W, due to post-glacial slumping and underlying Lias clay flows, classic cambering features and eroded gulls, evidence of frost shattering, debris and solifluction residues. A diverse fauna identified by Channon (1950), bivalves, brachiopods and corals are very common. The sequence is capped by the Upper Estuarine Clay, the lateral equivalent of the Hampen Marly Beds and part of the White Limestone Formation and is relatively rare, being restricted to south of the Oxfordshire boarder. Reference section for the Crickley Member, Cleeve Cloud Member, Scottsquar Member
Foss Cross Quarry	SP 056 092	SSSI GCR	GREAT OOLITE GROUP White Limestone Fm.: *(Ardley Mb., Shipton Mb.)*	This site shows an important, highly fossiliferous section through the middle part of the White Limestone Formation (Ardley & Shipton members). The site is noted particularly for the presence of the red alga *Solenopora* and is one of a few localities that have yielded zonally diagnostic Bathonian ammonites. The quarry is partially infilled but one face is preserved and exposes in the basal section c.1.9 m of the Shipton Member, a massive to rubbly, sparsely peloidal limestone, with abundant fossils, mostly bivalves and corals, with some gastropods. This passes up into the Excavata bed, marking the top of the member. Overlying this is c.6.58 m of the Ardley Member, the basal section comprising a ooidal, sandy marl bed, passing up into a sandy or argillaceous limestone, in turn passing up into a highly fossiliferous lime mudstone, the upper part peloidal ('Dagham Stone') capped with a sharp, bored hardground. Above this a cross-bedded ooidal, peloidal limestone with several marl beds, capped with the Solenopora Bed, containing pink/white-banded algal masses and coral fragments. This site, when compared with others in the area, allows for comparisons and contrasts to be made.
Fourmile Lodge Quarry	SO 960 021	RIGS	GREAT OOLITE GROUP Forest Marble Fm. *(Wychwood Beds)* *(Bradford Clay)* White Limestone Fm. *(Signet Mb.)*	This quarry exposes c.2.5 m of the Upper Bathonian Great Oolite Group, including an important basal section of the Forest Marble Formation. Displayed is c.1 m of the Signet Member, an ooidal limestone, overlain by a thin c.6-10 cm band of orange/brown clay, which may be equivalent to the Bradford Clay, this forms the base of the Forest Marble and is overlain by c.1.5 m of flaggy, cross-bedded shelly limestone, in which fossils are common (Pectinaceans and oysters).

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Frocester Long Barrow Quarry	SO 795 016	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm.	The site comprises a quarry section and track cutting. Exposed are key sections through the top of the Lias Group and lower part of the Inferior Oolite Group. Visible are the Cephalopod Bed and Cotteswold Sands form the Bridport Sand Formation and the Scissum Beds (Leckhampton Member) in the track cutting and Lower Limestone (Crickley Member), containing Richardson's "Pea Grit horizon" in the quarry section. Visible jointing, small faults, cross-bedding and erosional planes. Fossil fauna includes the ammonite *Harpoceras*, the nautiloid *Cenoceras* and belemnites. The site lies within a GWT nature reserve.
Grange Hill Quarry	SP 114 244	RIGS	GREAT OOLITE GROUP Taynton Limestone Fm. Fuller's Earth Fm. *(Eyford Mb.)*	A working quarry, exposing the Great Oolite Group; Fuller's Earth Formation (Eyford Member) and the Taynton Limestone Formation. The base of the quarry is in the Fuller's Earth Clay (Sharps Hill Formation). The Eyford Member varies here both vertically and laterally, at the southern end of the site demonstrating a fine-grained limestone with sparite cement lithology, at the northern end, medium-grained sandy limestone with sparite cement. Bedding appears near horizontal, finely laminated with small-scale cross-bedding and ripple marks. The contact between the two units is present but not visible.
Guiting Quarry	SP 078 302	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Harford Mb. Scottsquar Mb. Cleeve Cloud Mb.)*	An extensive working quarry exposing excellent sections through the lower part of the Inferior Oolite Group (similar to that seen at Cotswold Hills Quarry). The sequence exposes the Yellow Guiting Stone, White Guiting Stone (Cleeve Cloud Mb.), Oolite Marl, Upper Freestone (Scottsquar Mb.), Harford Sands and the Tilestones (Harford Mb.) The lowest unit exposed is the Yellow Guiting Stone: sandy, oolitic limestone, medium-grained and cross-bedded. White Guiting Stone: oolitic limestone, fine to medium-grained, fining up cycles, cross-bedded, top marked by oyster-encrusted hardground. Oolite Marl: fine-grained oolite, interdigitating into Upper Freestone: fine to medium-grained peloidal, ooidal limestone, fossiliferous (containing coral fragments) followed by a transition into a medium-grained, bioturbated bioclastic limestone. Harford Sands: sands with clay lenses interbedded with limestone bands. Tilestones: thin, flaggy, fine to medium-grained oolite. Bedding is essentially horizontal, some evidence of minor normal faulting. N-S trending fracturing. Reference section for the Cleeve Cloud, Scottsquar and Harford Members.
Hailey Farm Railway Cutting	SO 950 017	RIGS	GREAT OOLITE GROUP Forest Marble Fm. White Limestone Fm.	The site comprises two railway cuttings, on an active line, linked by a tunnel, with high, steep faces exposing near-horizontal Great Oolite Group, White Limestone Formation. Some basal Forest Marble Formation is present at the NW end of the west cutting. Lithology of oolitic limestone, poorly fossiliferous, well bioturbated with diagenetic bedding overprint.
Hampen Railway Cutting	SP 062 205	SSSI GCR	GREAT OOLITE GROUP White Limestone Fm. *(Shipton Mb.)* Hampen Fm. Taynton Limestone Fm. Fuller's Earth Fm. *(Eyford Mb.)*	This site is on the disused Andoversford to Bourton-on-the-Water railway line, over a kilometre in length and shows one of the more complete Great Oolite Group sections in the Cotswolds, including parts that are rarely exposed elsewhere, notably the Fuller's Earth Formation, Hampen Formation and basal White Limestone Formation. The site is also the type section for the Hampen Formation and reference section for the Taynton Limestone Formation. The site was originally described by Woodward (1894), recognised as the 'Marly Beds' and formalised as the 'Hampen Marly Beds' by Arkell (1933). The exposures are now quite obscured by vegetation.
Hams Gulley Brook	SO 754 900 to 757 903	RIGS	LIAS GROUP Dyrham Fm. Charmouth Mudstone Fm.	Rare exposure of the upper beds of the Charmouth Mudstone Formation, Echioceras Zone, exposed along an incised stream section. Silty laminated blue-grey soft clays, interbedded with hard argillaceous limestones. Abundant fauna; mostly fragments of belemnites, brachiopods, bivalves, gastropods and pyritised ammonites. The site is useful for sedimentology, stratigraphy studies at all levels of education, including research.

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Hard Stone Quarry	SO 989 269	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Scottsquar Mb., Cleeve Cloud Mb.)*	Within Cleeve Common SSSI, a re-excavated quarry, exposing the Cleeve Cloud Member (Lower Freestone) and the Scottsquar Member (Oolite Marl, Upper Freestone). The Lower Freestone is cross-bedded, its upper boundary and contact with the overlying Oolite Marl can be clearly seen, a thin hardground with a very finely rippled surface in places. The whole of the Oolite Marl sequence and its contact with the overlying Upper Freestone within the Scottsquar Member can also be seen. The Oolite Marl is highly fossiliferous and excellent specimens of the brachiopod *Plectothyris fimbria* can be found.
Haresfield Hill	SO 819 088	SSSI GCR	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm.	An outlier of the main hill-mass, the site exposes the basal part of the Inferior Oolite Group, the Leckhampton Member (containing the Scissum Beds) and Crickley Member of the Birdlip Limestone Formation and the underlying Bridport Sand Formation (Cephalopod Bed) at the top of the Lias Group. The site shows one of the most extensive and well exposed sections available of the Scissum beds. The site is important for its exposure of the Cephalopod Bed at the top of the Lias Group and the overlying Leckhampton Member, it is one of the few localities where the Lower/Middle Jurassic boundary can be examined, making it an important site for stratigraphical and palaeontological studies. The ammonites and brachiopods have been subject of important detailed studies.
Harford Railway Cutting	SP 136 218	SSSI GCR	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Aston Limestone Fm. *(Notgrove Mb., Gryphite Grit Mb., Lower Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Harford Mb.)*	This site is on the disused Andoversford to Bourton-on-the-Water railway line, exposing an excellent section through the middle and upper parts of the Inferior Oolite Group, from the upper part of the Birdlip Limestone Formation, to the middle part of the Salperton Limestone Formation. It was first described by Buckman (1890), mentioned by Woodward (1894), summarised by Arkell (1947b), re-examined by Parsons (1976b). The section shows a number of minor reverse and normal faults (connected with cambering and gulling). A gull crosses the cutting, displayed as a graben 35 m wide, with step-faulted margins with the strata down-faulted by c.5 m. The Notgrove Member shows marked thinning and erosional non-sequence at its top due to its proximity to the Vale of Moreton Axis. The succession has yielded one of the most complete records of consecutive ammonite faunas, ranging from late Aalenian to late Bajocian in age. Also rhynconellids, oysters, bivalves, corals. It is the type section for the Harford Member and the Aston Limestone Formation and reference section for the Salperton Limestone Formation, Notgrove Member, Lower and Upper Trigonia Grit Member and the Clypeus Grit Member.
Hillside Wood Quarry	ST 742 988	RIGS	Head INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Cleeve Cloud Mb. Crickley Mb.)*	This site lies within the Stinchcombe Hill biological SSSI and represents one of the most westerly outcrops of Lower Limestone (Crickley Member) and possibly with Lower Freestone (Cleeve Cloud member). The section shows some important iron stained irregular hardgrounds not seen in quarries to the east. The Pea grit facies appears to have wedged out or has not developed this far west. Lithology includes biomicrites, ooites, pebble beds and pellitiferous oolites. Few whole macrofossils seen but many brachiopod and bivalve clastic remains. Overall the exposure is severely frost shattered and jointed, the lower beds show current cross-bedding, the upper beds planar bedding, also several pebble conglomerate beds. The sequence is overlain by post glacial head deposit.
Horcott Pit	SU 149 995	RIGS	Upper Thames Valley Fm. (Northmoor Mb.)	Good exposure of Upper Thames Valley (Northmoor Member) 1st Terrace sands and gravels deposited during Late Pleistocene cold phase, overlying Oxford Clay Formation (not exposed). Similar lithology to that seen at Thornhill Farm Pit to the east; deposits derived from local Middle Jurassic limestones, abundant water worn Jurassic remanie fossils, possibility of cold phase vertebrate remains such as mammoth and reindeer, although none found as yet.

SITE NAME	GRID REF’	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Hornsleasow Quarry (Snowshill Quarry)	SP 131 322	SSSI GCR	GREAT OOLITE GROUP Taynton Limestone Fm. Fuller’s Earth Fm. Chipping Norton Limestone Fm.: *(Chipping Norton Mb., Hornsleasow Clay Hook Norton Mb.)* INFERIOR OOLITE GROUP Salperton limestone Fm. *(Clypeus Grit Mb.)*	The site exhibits excellent sections through the lower part of the Great Oolite Group, possibly one of the best sections of Lower Bathonian in the North Cotswolds. The underlying Inferior Oolite Group, Clypeus Grit Member is not well exposed though. The middle part of the section (Fuller’s Earth Formation) is regarded as being attenuated and demonstrates a facies that is transitional between the Fuller’s Earth Formation (typically developed further south in the Cotswolds) and of the Sharp’s Hill Formation in Oxfordshire. Much of the exposed succession is fossiliferous, especially the Coral Bed, within the Fuller’s Earth Formation and the Hornsleasow Clay, within the Chipping Norton Limestone Formation, the latter yielding an extensive and very important vertebrate fauna, including: pterosaur, turtle, lizard, frog and salamander remains. The Clypeus Grit and Taynton Limestone formations have both yielded age diagnostic ammonites. The site is well documented, since first briefly mentioned by Richardson (1929b) and an account relating to the vertebrate-bearing Hornsleasow Clay was published by Metcalf *et al*. (1992). Of particular interest is an erosional surface (palaeokarst) running across the site within the Chipping Norton Limestone Formation, at the top of the Hook Norton Member, above which the Hornsleasow Clay has in-filled. This clay member has high kaolinite content and is indicative of weathering in a warm, humid climate, supporting the idea that the underlying surface represents a subaerially formed palaeokarst. In general, the Chipping Norton Formation appears as a cross-bedded oolite, its top surface is capped by a bored and oyster-encrusted hardground, overlain by the Fuller’s Earth Formation. The basal section appears highly variable, sandy limestones and shelly clays pass laterally into ooidal limestones, containing gastropods and bivalves and corals. The contact with the overlying Taynton Limestone Formation is no longer visible but the coarse-grained shelly oolite, typical of the formation is exposed in the higher parts of the quarry. General dip of the strata is approximately 6° to the north, running N-S through the site is a shatter fault zone and evidence of minor faulting.
Huddingknoll Hill	SO 846 107	RIGS	Head INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Aston Limestone Fm. *(Notgrove Mb., Gryphite Grit Mb., Lower Trigonia Grit Mb.)*	This site comprises a quarry on Huddingknoll Common and two roadside verges. The site is extremely important in relation to the geology of the Cotswolds, especially the Stroud area. Exposed are various members from the Aston and Salperton Limestone Formations, found to the north of and near Stroud, preserved by the Painswick Syncline. Lithologies are predominantly biosparite, micrites, often sandy, shelly and shell detrital in parts. The structure here is complex, as a result of post-glacial slipping and cambering. The site also shows many sedimentary structures as well as evidence of head deposits and a diverse range of fauna.
Huntsmans Quarry	SP 125 259	SSSI GCR	GREAT OOLITE GROUP Taynton Limestone Fm. Fuller’s Earth Fm. *(Eyford Mb., Fuller’s Earth Clay)*	An extensive working quarry, representative of the quarries around the Eyford Hill area working the Fuller’s Earth Formation Eyford Member, the ‘Cotswold Slates’. Huntsmans Quarry is the type locality for this member and provides the best remaining sections through the Eyford Member. The Eyford Member is a fine-grained sandy limestone, planar-laminated, cross-bedded and trough cross-bedded with rippled surfaces and a sharp eroded and burrowed top surface. The overlying Taynton Limestone Formation is a coarse-grained, ooidal limestone, cross-bedded, with oysters, bivalves and gastropods. The Eyford Member has yielded a diverse range of flora and fauna, including turtles, crocodiles, dinosaurs, pterosaurs, fish, starfish, insects, an important suite of ammonites of the *Progracilis* Zone and numerous bivalves, brachiopods and gastropods.
Incline Quarry	SO 950 187	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Cleeve Cloud Mb.)*	Within Leckhampton Hill SSSI, this disused quarry worked unconsolidated oolitic limestone gravel used in the construction of the main tramway ramp from the limekilns down to Daisy Bank Lane. The quarry is located in a rotated and slumped block of the Birdlip Limestone Formation on the escarpment, the quarry floor dips in towards the escarpment at approximately 10° SE, instead of the normal tectonic dip of 1-2° SE.

SITE NAME	GRID REF’	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Jackdaw Quarry	SP 077 309	SSSI GCR	INFERIOR OOLITE GROUP Aston Limestone Fm. *(Notgrove Mb., Gryphite Grit Mb., Lower Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Harford Mb. T ilestones Snowshill Clay, Harford Sands, Naunton Clay, Scottsquar Mb., Cleeve Cloud Mb.)*	The site exposes a fine section through the upper part of the Birdlip Limestone Formation and Notgrove Member of the Aston Limestone Formation. The quarry is particularly important for displaying a complete section of the Harford Member. The quarry was first described by Woodward (1894) when only the lower part of the sequence was exposed. Buckman (1901) described the higher beds exposed in the nearby Hornhill Quarry and in 1972 the two quarries were joined but now are partially in-filled, with an excellent exposure remaining in the northern face. The quarry is within 1 km of Guiting Quarry to the south, but shows considerable variation to that seen at Guiting. The section visible now is much as described by Parsons (1976b). The site is the reference section for the Cleeve Cloud, Scottsquar, Harford and Lower Trigonia Grit Members.
Jarvis Quarry, Nr. Coates	SO 995 998	RIGS	GREAT OOLITE GROUP Forest Marble Fm. *(Reef Bed)*	Approximately 9 m of Mid to Upper Bathonian, Great Oolite Group was formerly exposed at this quarry. The Upper Fuller’s Earth Formation (Athelstan Oolite Member, Reef Bed) and Forest Marble Formation were represented. The Athelstan Oolite is now obscured. The ‘Reef Bed’ is a rare example of a Jurassic patch reef. The SSW face of the lower level quarry is now largely overgrown but there are still a few c.1-2 m high exposures of the Forest Marble visible. The bored surface at the base of the Forest Marble, indicated by Cope *et al*. (1977) is still visible. Limited fauna observed although the Forest Marble is full of shell debris and echinoid spines.
Kemble Railway Cuttings	ST 975 976	SSSI GCR	GREAT OOLITE GROUP Forest Marble Fm. White Limestone Fm. *(Signet Mb., Athelstan Oolite)*	This site comprises three separate sections in railway and road cuttings, including the type section for the Kemble Beds (equivalent to and now recognised as the Signet Member) and exhibit excellent exposures of basal Forest Marble coral patch reefs and inter-reef sediments. They also provide a key reference section for correlating the successions in the Minchinhampton, Cirencester and Bath areas. The ‘Bradford Fossil Bed’ at the base of the Forest Marble Formation, is of importance as it has yielded the ammonite *Clydoiceras hollandi*, from the Bathonian *Discus* Zone.
Kilkenny Quarry	SP 005 185	RIGS	INFERIOR OOLITE GROUP Aston Limestone Fm. *(Gryphite Grit Mb., Lower Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb. Cleeve Cloud Mb.)*	This site contains good exposures of mid-Aalenian to lower Bajocian Inferior Oolite. The quarry is located between similar sections at Leckhampton Hill and Chedworth Railway Cutting and is therefore useful for comparative stratigraphy studies. Exposed is: Pea Grit, Lower Freestone, Oolite Marl, Upper Freestone (Harford Member absent), Lower Trigonia Grit and Gryphite Grit. Varying lithologies, including; oolites, micrites, pisolitic interdigitations, bioclastic and rubbly beds. Rich fauna yielded, many abraded shells, brachiopods, bivalves, gastropods, oysters, belemnites and ammonites. Beds dipping 20°-40° WSW, through rotational slipping and cambering, inferred faulting, fissures, cross-bedding, bored surfaces and lag deposits. Reference section for the Scottsquar Member.
Knapp House Quarry	SO 925 147	SSSI GCR	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb., Cleeve Cloud Mb.)*	A small complex of disused workings on the Cotswold scarp just north of Birdlip, situated approximately on the Birdlip Anticline. Exposed is an attenuated succession of the Inferior Oolite Group (Salperton Limestone Formation) resting directly on the Birdlip Limestone Formation. The eroded surface between the two formations is bored and oyster-encrusted. It is a reference section for the Birdlip Limestone Formation, Cleeve Cloud Member, Scottsquar Member and the Upper Trigonia Grit Member.
Leach Bridge Cutting	SP 144 089	RIGS	GREAT OOLITE GROUP White Limestone Fm.	This site is now partially overgrown and was considered by Richardson (1933) to be an important section. Exposed is the White Limestone Formation, including at the top the ‘Kemble Beds’. The ‘Kemble Beds’ here are of the Forest Marble facies; some horizons are highly fossiliferous, yielding mostly bivalves.

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Leckhampton Hill & Charlton Kings Common	SO 946 183 SO 952 187 SO 951 179	SSSI GCR	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Upper Trigonia Grit Mb.)* Aston Limestone Fm. *(Notgrove Mb., Gryphite Mb., Lower Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb., Cleeve Cloud Mb., Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm.	The quarries at this location have been the subject of much study for over 150 years. They provide one of the best and thickest sections through the Middle Jurassic Inferior Oolite Group in the Cotswolds and all the quarries combined expose a sequence of over 60 m thick. Represented are type sections for the Birdlip Limestone Fm. (Leckhampton Mb., Cleeve Cloud Mb, Lower Trigonia Grit Mb, Gryphite Grit Mb.). Other key features include: largely absent Cotteswold Sand facies and highly attenuated Cephalopod Bed, Scissum beds thicker than in the south Cotswolds. The Lower Limestone is also greatly attenuated relative to the south Cotswolds, the Pea grit facies is thinner than at Crickley Hill and confined to the lower part of the section; large-scale cross-bedding in the Lower Freestone; channelling in the upper part of the Upper Freestone. Numerous unconformities and excellent hardgrounds, wide range of sedimentary structures, fine examples of cambered strata, rotational slipping, slumping, faulting and gulling. A diverse fauna within various members. Lycett (1853) recorded over 184 species.
Leigh's Quarry (Selsley Common)	SO 826 025	SSSI GCR	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb., Cleeve Cloud Mb.)*	The site is located to the southern end of Selsley Common SSSI. It exposes an excellent, easily accessible section of Inferior Oolite Group (Birdlip and Salperton Limestone Formations.) The sequence shows the unconformable contact between Birdlip and Salperton Limestone Formations, missing completely is the Aston Limestone Formation as a result of the Bajocian denundation. Exposed is the Cleeve Cloud Member (Lower Freestone); massive bedded oolite with large-scale cross-bedding, the Scottsquar Member (Upper Freestone); oolitic limestone with marl bands, cross-bedded in parts, hardground at the top, the Upper Trigonia Grit Member; rubbly, shelly limestone, minor encrusted hardground at top, Clypeus Grit Member; limestone, fossiliferous, minor bored hard ground in places. Generally the sequence is fossiliferous, well-developed cambering and gulling, gulls in-filled by travertine cemented breccias.
Little Herbert's Railway Cutting	SO 965 196	RIGS	Cheltenham Sand and Gravel. LIAS GROUP Charmouth Mudstone Fm.	Rare but limited exposure of Cheltenham Sand & Gravel. Type Section for the Cheltenham Sand and Gravel. The site exposes a sequence of Lias clays overlain by unconsolidated Quaternary sand, limestone and ironstone gravel deposits of re-worked, local material from the Inferior Oolite Group.
Little London Quarry	SO 847 036	RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Upper Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Cleeve Cloud Mb.)*	A small, disused quarry on the west-facing slope of Rodborough Common SSSI. Exposed is the Cleeve Cloud Member (Lower Freestone), an oosparite and the Upper Trigonia Grit, a biosparite, highly fossiliferous with abundant brachiopods. These two members are separated by a discontinuity, represented by a 1-2 cm thick layer of carbonate mudstone. The site demonstrates good post-glacial features, cambering and gulling, plus head deposits in the valley bottom.
Lower Limekilns Quarry	SO 949 185	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Crickley Mb. Leckhampton Mb.)* LIAS GROUP Whitby Mudstone Fm.	Within Leckhampton Hill SSSI, a disused quarry, with the remains of a once extensive lime kiln plant. Exposed are clays of the Whitby Mudstone Formation, the Leckhampton Member (Scissum Beds) and the Crickley Member (Lower Limestone, Pea Grit, Lower Freestone). The Leckhampton Member is one of the most fossiliferous parts of the Birdlip Limestone Formation, yielding brachiopods, large myacean bivalves (*Pholadomya sp.*), belemnites and ammonites. The Crickley Member is moderately fossiliferous, yielding brachiopods, bivalves, gastropods, echinoids and corals. Normal E-W faulting with a northerly downthrow can be observed at the southern end of the middle quarry. This location is the type section for the Leckhampton Member.

SITE NAME	GRID REF’	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Lower Lodge Wood	ST 781 921	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Crickley Mb., Leckhampton Mb.)*	An excellent typical Cotswold hanger wood which runs along a remote Cotswold spur. The site provides access to a 90m long exposure found on the east bank above the path running south to north. The exposure exhibits the Scissum Beds and Lower Limestone. The Scissum beds are not a sandy limestone, as expected but silty. Isolated samples of the Scissum Beds contain brachiopods and bivalves. Bedding appears virtually horizontal but in parts the site shows interesting effects of frost damage, cambering and landslipping from previous ice-ages, with recorded dips of c.20° to the east.
Luckley Farm Quarry	SP 161 287	RIGS	GREAT OOLITE GROUP Chipping Norton Limestone Fm. Fuller’s Earth Fm. *(Eyford Mb.)*	A recently exposed quarry showing flagstones of the Chipping Norton Limestone Formation, dipping in an ESE direction across the floor of the excavation. An old quarry adjacent to this shows these same beds being overlain unconformably by a horizontal set of beds, interpreted as low members of the Great Oolite Group (possibly Eyford Member?) Medium to coarse-grained oolitic calcarenites form a flaggy sequence of beds (Chipping Norton Limestone Formation) dipping 18° to 28° to ESE, open jointed, unconformably overlain by oolitic limestones (Eyford Member?). The Chipping Norton beds yield terebratulids and rhynconellids.
Marmontsflat Quarry	SO 803 015	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. Scottsquar Mb. *(Cleeve Cloud Mb., Crickley Mb.)*	A disused quarry and adjacent cutting exposing rocks from the Birdlip Limestone Formation. The site is regionally important as it contains rock facies, particularly at the top of the Lower Limestone which are intermediate between those found in the north of the area (Pea Grits) and those found in the south (oolites). The quarry also adds to the geological sequence of rocks exposed in Woodchester Park. Exposed are the Lower Limestone / Pea Grit (Crickley Member) well displayed in a large prominent in situ block in the centre of the quarry and the cutting on the west side. This is overlain by the well-bedded Lower Freestone (Cleeve Cloud Member), the top unit of which seems to be a hardground c.15-20 cm thick, with the uppermost 2-3 cm consisting of Oolite Marl (Scottsquar Member). There is an apparent dip of 6° E, probably related to cambering. The Lower freestone is highly jointed and fractured and possibly contains minor faulting in places. Generally not a fossil-rich site but contains Rhynchonellid brachiopods in the Lower Limestone and bivalves.
Middle & Upper Limekilns Quarries	SO 947 184 SO 950 186	RIGS	INFERIOR OOLITE GROUP Aston Limestone Fm. *(Gryphite Grit Mb. Lower Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb. Cleeve Cloud Mb.)*	Within Leckhampton Hill SSSI, an isolated and difficult to reach sequence exposing approximately 45m from within the Inferior Oolite Group. The middle quarry exposes and is the type section for the Cleeve Cloud Member (Lower Freestone), the upper quarry exposes the Scottsquar Member (Oolite Marl and Upper Freestone), the Lower Trigonia Grit and Gryphite Grit Members, and is the type section for the latter two members. The most fossiliferous beds are: Oolite Marl (*Plectothyris fimbria*), Lower Trigonia Grit (brachiopods; terebratulids, rhynconellids) and Gryphite Grit (*Gryphaea* sp.)
Midger Wood Tufa Stream	ST 796 894	SSSI RIGS	Alluvium INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Upper Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Cleeve Cloud Mb., Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm.	A small stream flowing south and into a larger stream running through a valley NE to SW, exhibiting small tufa terraces at their confluence. The stream cuts through Inferior Oolite Group, Birdlip Limestone Formation (Leckhampton & Crickley Members). The main tufa terrace is approximately 5m long by 2m wide.

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Minchinhampton Common	SO 855 015	SSSI GCR	GREAT OOLITE GROUP White Limestone Fm.	A series of disused quarries (now mostly infilled and lost) once exposing the Bathonian White Limestone Formation (Great Oolite Group) and celebrated fossil sites, made famous by the work of Morris and Lycett (1851-1855) in their monograph on the molluscan faunas of the Great Oolite of Minchinhampton. In it, they describe over 150 new species of gastropods and bivalves from the common. Most of the small quarries are now lost, the only remaining site is Crane Quarry, re-excavated in 1984, exposing two new faces, although no major exposure exists. Exposed are two faces: the south-west face shows c.1.8 m of massively bedded, fine to medium-grained, ooidal and peloidal limestone, with marly and rubbly beds, overlain by c.2.5 m of medium-grained ooidal and shell-fragmental limestone, cross-bedded in one large co-set. The north-east face shows c.2 m of coarse-grained, shelly, shell fragmental and ooidal limestone, with large-scale cross-bedding, in turn overlain by c.2 m of flaggy, medium-grained, cross-bedded, ooidal limestone. The site is an important Bathonian locality but complex vertical and lateral facies changes make interpretation of the local stratigraphy difficult. The limited section now exposed is representative of the Athelstan Oolite, featuring the 'planking' and yielding a diverse bivalve and gastropod fauna.
Montserrat Quarry	SO 855 033	RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb. Upper Trigonia Grit Mb.)* Aston Limestone Fm. *(Lower Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb.)*	A large, shallow disused quarry in the Rodborough Common area. Exposed are rocks from the upper part of the Inferior Oolite Group: Clypeus Grit Member, Upper Trigonia Grit Member (Salperton Limestone Formation), Lower Trigonia Grit Member (Aston Limestone Formation), and the Scottsquar Member (Birdlip Limestone Formation). Of particular interest here, is an excellent exposure of the hardground developed at the top of the Scottsquar Member. This is overlain by the Upper Trigonia Grit Member for most of the exposure, however at the northern end of the quarry, there is another hardground exposed c.5 m below the main unit. This may be due to faulting/cambering but more probably it represents the hardground below the Lower Trigonia Grit - if this is proven then this is a very important outcrop. Lithologies vary here: Scottsquar Member; oolitic limestone, top bed hard and well bored: Upper Trigonia Grit; shelly oolitic limestone, with some sandy pockets: Clypeus Grit Member; rubbly, oolitic limestone. Bedding appears planar in all beds, no cross-bedded units observed. A possible fault (obscured) with 5m downthrow located to north end of quarry. Possible exposure of Lower Trigonia Grit at south end of quarry. Bivalves and brachiopods common in The Clypeus and Upper Trigonia Grit Members, Scottsquar Member not very fossiliferous but the top 20 cm is heavily bored.
New Farm Sinkhole	SO 976 168	RIGS	GREAT OOLITE GROUP Fuller's Earth Fm. Salperton Limestone Fm.	This site displays a sink hole, a very rare landform on the Cotswolds. The underlying stratigraphy is Salperton Limestone Formation, overlain by the Fuller's Earth Formation. The sink hole is roughly triangular, with dimensions of approximately 15m long, 6-7m wide and 4-5m deep. It occurs where water crossing over the impermeable Fuller's Earth Clays (or through the clays in thin limestone bands) reach the junction with limestones of the Salperton Limestone Formation. The clay here is very thin and has been 'breached'. Mentioned by Richardson (P.C.N.F.C 1913) and Goudie & Parker (1996).
New Park Quarry, Longborough	SP 175 282	SSSI GCR	GREAT OOLITE GROUP Chipping Norton Limestone Fm. INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb.)*	A very important site, yielding abundant, well preserved remains (disarticulated but well preserved) of crocodiles (Steneosaurus) and dinosaurs (*Megalosaurus, Cetiosaurus* and *Stegosaurus*). This fauna is from the Chipping Norton Limestone Formation, Lower Bathonian (Zigzag Zone) and is the oldest Jurassic dinosaur assemblage in Britain. At the site is a relatively thick development of the Chipping Norton Limestone, unconformably overlying the Inferior Oolite Group, Clypeus Grit Member (seen in adjacent road cutting). Exposed are mainly massive, oolitic, fine bioclastic limestones (coarsely oolitic in places) in N-S aligned quarry face, with a sandier member visible in the NW corner. Also seen are manganese-rich nodules, a sandy marl containing black phosphatised pebble-like bodies. Structurally, the strata at the north end of the exposure dips 5° to N. A small fault in the extreme NW corner is suggested by a local downfolding to the SW.

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Nibley Knoll	ST 744 956	SSSI GCR	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Cleeve Cloud Mb., Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm.	The site comprises an incised lane and quarry section. The lane cutting shows a section of the Cotteswold Sands (Bridport Sand Formation) overlain, although poorly exposed by the Cephalopod Bed and the Leckhampton Member (base of the Inferior Oolite Group). Stratigraphically above this, exposed in the quarry, is the Crickley Member (Birdlip Limestone Formation) capped by a well-developed, encrusted and bored hardground representing the Bajocian denundation, which completely removed the missing Aston Limestone Formation. Above this are the highly fossiliferous Upper Trigonia Grit Member and the Clypeus Grit Member. Also visible are a number of minor faults and gulls (described by Donovan, 1973) the latter infilled with limestone rubble and travertine. The site is a reference section for the Birdlip Limestone Formation.
North Nibley Quarry	ST 736 956	RIGS	LIAS GROUP Marlstone Rock Fm.	Located on the sub-edge terrace of the Cotswold Scarp, unlike many old Marlstone quarries, this site is not presently overgrown and can be studied and is ideal for sedimentological and palaeontological studies including research. Limestone lithology: Lias Group, Marlstone Rock Formation, (*Pleuroceras Spinatum* / *Amaltheus Margaritatus* Zones). Abundant shelly fossils include belemnites, brachiopods, bivalves, crinoid columnella fragments and occasional *Pleuroceras*.
North Woodchester Rail Cutting	SO 841 030	RIGS	LIAS GROUP Marlstone Rock Fm.	Rare exposure of the Marlstone Rock Formation, the rocks are highly fossiliferous, containing a variety of bivalves, including *Gryphaea* and *Modiolus* plus brachiopods and belemnites.
Notgrove Railway Cutting	SP 084 209	SSSI GCR	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb. Upper Trigonia Grit Mb.)* Aston Limestone Fm. *(Notgrove Mb.)*	Also referred to as "First Cutting west of Notgrove" (Buckman 1890). Another site on the disused Andoversford to Bourton-on-the-Water railway line. The site exposes one of the best sections of the uppermost part of the Inferior Oolite Group in the Cotswolds. It was first described by Buckman (1890) then by Woodward (1894). Only the upper part of the Notgrove Member is now visible as a massive and unfossiliferous unit. Its upper surface is uneven, eroded and a well-developed hardground, bored and oyster and serpulid encrusted. The overlying Upper Trigonia Grit is highly fossiliferous, with common bivalves and brachiopods and rare ammonites. The top unit, the Clypeus Grit is probably the best and most complete section in the Cotswolds and is also fossiliferous, particularly with brachiopods (*Stiphrothyris*) and in the uppermost the *Clypeus ploti*. Ammonites from this locality (from the Upper Trigonia Grit Member) indicate Upper Bajocian age from the *Acris* Subzone of the *Garantiana* Zone. The sharp junction between the Upper Trigonia and Clypeus Grit Members suggests a minor non-sequence, which can also be seen at other locations. The locality is the type section for the Salperton Limestone Formation and the Upper Trigonia Grit, Clypeus Grit and Notgrove members.
Oathill Quarry	SP 111 288	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Scottsquar Mb., Cleeve Cloud Mb.)*	A large, disused quarry, exposing a sequence of Inferior Oolite Group limestones from the Birdlip Limestone Formation. The main sequence of strata appears horizontally bedded and exhibits marked angular cross-bedding (27°) in the lower section (Lower Freestone facies?). Lithologies are variable; massive yellowish oolites, shell fragmental oolite, pale oolites, fossiliferous calcite mudstones. Within the sequence are a number of non-sequences and an unusual brecciated limestone. Fossils mostly recovered from the uppermost weathered blocks of the calcareous mudstones, including brachiopods, bivalves and echinoids.
Old Quarries, Gretton	SP 012 295	RIGS	LIAS GROUP Whitby Mudstone Fm. Marlstone Rock Fm. Dyrham Fm.	An historically and scientifically important vertebrate site containing the famous fish, insect and reptile bed of the Whitby Mudstone Formation. Once worked, now overgrown with little exposure visible.

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Pen Wood Quarry	SO 823 023	RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Cleeve Cloud Mb.)*	Site exposing members from the Inferior Oolite Group, disturbed by slope movements at the end of the last ice-age. The site is valuable as it illustrates the disappearance of some important strata seen on Selsley Common and the Cotswolds to the north-east but not in the south Cotswolds. Exposed are Cleeve Cloud Member (Lower Freestone), Upper Trigonia Grit and Clypeus Grit. The Oolite Marl and Upper Freestone are missing here, as at Selsley Gully, but present at Leigh's Quarry SSSI, 800m NE of this location, demonstrating the major non-sequence within this part of the Inferior Oolite Group. Lithologies vary including a variety of medium to coarse-grained shelly, peloidal and oolitic limestones, with local intraformational conglomerates (pebbles and cobbles). Also evident are tufa deposition and travertine crusts. The site is situated on a scarp crest location, strata is essentially horizontal. Joint sets have opened to form gulls and rotational shearing is evident and has produced a cave. Solution action down a gull has produced a wavy, irregular karstic surface (*viz* 'rundkarren'), which is an unusual feature in this type of environment.
Rodborough Common (Including Fort Quarry)	SO 851 040	SSSI	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Aston Limestone Fm. *(Gryphite Grit Mb., Lower Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb.)*	This is one of the few remaining sections of the once numerous Rodborough localities, exposing a good but incomplete section through the Inferior Oolite Group. The Buckmani Grit (Gryphite Grit Member) and Lower Trigonia Grit Member from the Aston Limestone Formation are rarely present or exposed in the Stroud area; this area must represent one of the most southerly exposures of these lithological units as they are progressively cut out beneath the overlying Upper Trigonia Grit Member. A very important and abundant fossil site, and many species, particularly of bivalves were first defined from specimens collected here in the late nineteenth century by Lycett & Morris; many of these are now in the Natural History Museum, London. Reference section for the Upper Trigonia Grit Member,

SITE NAME	GRID REF’	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Rolling Bank Quarry and Pot Quarry	SO 987 266 SO 986 267	SSSI RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Aston Limestone Fm. *(Rolling Bank Mb., Notgrove Mb., Gryphite Grit Mb.)* Birdlip Limestone Fm. *(Cleeve Cloud Mb.)*	A very important site exposing members from the Birdlip, Aston and Salperton Limestone Formations, including a unique sequence from the top of the Aston Limestone Formation, the Rolling Bank Member, of which the upper beds, the Phillipsiana and Bourguetia Beds are not found anywhere else in the Cotswolds. This is due to the location of the quarry, in the centre of a small graben which has preserved the section in a down-faulted block, dropped by approximately 30m. The bounding faults to this graben can be seen at the northern end of the quarry, showing a polished foot-wall overlain by fault breccia, bringing the Trigonia Grit and Rolling Bank members into contact with the Cleeve Cloud Member. Also exposed is the boundary between the Middle and Upper Inferior Oolite, the unconformable contact between the Aston and Salperton Limestone Formations. Although here this section is the most complete, there is continued evidence of a break at the boundary, where a bored and oyster-encrusted hardground is developed at the top of the Phillipsiana Bed. In the adjacent Pot Quarry, the two lower members of the Aston Limestone Formation, the Gryphite Grit and Notgrove Freestone and the basal member of the Rolling Bank Member, the Witchellia Grit can be seen. Here the Notgrove Member is fully exposed, resting on a sharp, uneven surface of the Gryphite Grit Member. Its contact with the overlying Witchellia Grit is also sharp and irregular, with possible borings, indicating a break in deposition. The strata in Pot quarry exhibit a steep dip, showing the tectonic separation from the main hill mass and the Rolling Bank Graben. Rolling Bank Quarry especially, yields a diverse fauna containing: echinoids; *Clypeus ploti*, ammonites; *Ludwigia murchisonae*, bivalves; *Lopha marshi*, *Gervillela acuta, Pleuromya uniformis, Pholadamya lirata, Radulapecten vagans, Entolium corneolum, Trigonia* sp. brachiopods; Rhynchonellids. gastropods, belemnites and corals. Rolling Bank Quarry is the type section for the Rolling Bank Member and reference section for the Upper Trigonia Grit and Clypeus Grit Members.
Sand Mine Quarry	SO 988 258	RIGS	INFERIOR OOLITE GROUP Aston Limestone Fm. *(Lower Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Harford Mb.)*	Within Cleeve Common SSSI, a small sandpit, once extracting quartz-rich Harford Sands for use in the ceramics industry. Exposed are c.1.8m of the relatively rare Harford Member (Harford Sands and Snowshill Clay) unconformably overlain by c.0.5m of the Lower Trigonia Grit Member. The Harford Member is rarely exposed in the Cotswolds and here comprise soft sands with large doggers (sandstone concretions cemented with calcite cement). The Snowshill Clay is the upper part of the Harford Member and has been sampled and a taxa of over 100 specimens indicate a fresh/brackish water environment (freshwater lagoon) in comparison with the exclusively marine environment above and below. Also of archaeological interest are pick/tool marks made by the quarrymen in the Harford Member from the late nineteenth century.
Scar Hill Quarry	ST 857 996	RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Birdlip Limestone Fm *(Cleeve Cloud Mb.)*	An abandoned quarry and mine show good development of typical Inferior Oolite Group in the area. There are also interesting contrasts with the nearby Balls Green Quarry (*viz* absence of Oolite Marl and thickening of micrite facies of Salperton Limestone Formation). The mine provides an opportunity for 3-D examination of the strata. Limestone lithologies of biosparites, oosparites and development of dripstones. Typical Inferior Oolite fauna, including; *Trigonia sp.*, terebratulids and rhynchonellids. Evidence of slight normal faulting (downthrow c.0.5 m) and well exposed planed and bored unconformable contact between Birdlip and Salperton Limestone Formations (Bajocian unconformity).
Scottsquar Hill Quarry	SO 845 092	RIGS	INFERIOR OOLITE GROUP Aston Limestone Fm. *(Lower Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb., Cleeve Cloud Mb.)*	A large, if somewhat inaccessible exposure of Inferior Oolite Group (Birdlip and Aston Limestone Formations), including a section of the Lower Trigonia Grit, preserved here in the Painswick Syncline. The exposure exhibits good planed and bored hardgrounds between each rock unit. Lithologies include biosparites, biomicrites, oosparites and oobiosparites. Lower Freestone shell fragmental, Oolite Marl/Upper Freestone moderately fossiliferous, Lower Trigonia Grit fossiliferous*; Pleuromya, Trigonia, Stiphrothyris* all common. Good development of gulls, cross-bedding in the Lower freestone. Much of the exposure is obscured by vegetation growth. Type section for the Scottsquar Member.

SITE NAME	GRID REF’	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Selsley Common New Inn Sites	SO 830 033	SSSI	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb., Cleeve Cloud Mb., Crickley Mb.)*	Located towards the northern end of Selsley Common SSSI, combined with other sites on the common and others in the area, this site helps to clarify the stratigraphical relationships and tectonic history of the Aalenian-Bajocian succession in the Cotswolds. The site provides an excellent cross-section of the Inferior Oolite Group. Included within the succession here is the Oolite Marl (Scottsquar Member) making its most southerly occurrence, resting unconformably beneath the Upper Trigonia Grit Member and is capped by an excellent example of hardground development. As with other locations on Selsley Common and in the area, the Aston Limestone Formation is missing. The site is of great value for all levels of education and research.
Selsley Gulley	SO 825 024	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Cleeve Cloud Mb., Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm. Whitby Mudstone Fm.	This site is the southernmost of Selsley Common and exposes a virtually continuous section from the top of the Lias Group through to near the top of the Lower Inferior Oolite (Birdlip Limestone Fm). Of interest here is the “Pea Grit” facies (Cleeve Cloud Member) which appears to have thinned out between here and the sites to the northeast of the Common. Also of interest here is the removal of most or possibly all of the Upper Freestone/Oolite Marl (Scottsquar Member) found in Leigh’s Quarry to the northeast.
Shakespeare Quarry	ST 813 913	RIGS	GREAT OOLITE GROUP Forest Marble Fm. White Limestone Formation *(Athelstan Oolite)*.	The quarry exposes Upper Bathonian limestones from the Great Oolite Group, the Athelstan Oolite (White Limestone Formation) and the basal section of the Forest Marble Formation. The sequence is unusual in that the Athelstan Oolite does not display a hardground at its upper boundary and appears to gradually grade up into the more shelly, coarser limestones of the Forest Marble. The Coppice Limestone is also surprisingly absent from the sequence, despite the type section site being nearby. The exposed sequence offers potential for enhancing comparative studies of Great Oolite facies and palaeoenvironmental changes. Lithologies: Athelstan Oolite; white, fine-grained oosparite, becoming more shelly and coarser higher in the sequence, no fossils observed, good cross-bedding especially clear in basal section. Forest Marble; shelly oobiosparite, containing sparry calcite patches, shell fragmental, well cemented, orange/brown limonite staining common. Containing small whole Terabratulid brachiopods

SITE NAME	GRID REF’	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Shorncote Quarry	SU 028 968	RIGS	Upper Thames Valley Fm. *(Northmoor Mb.)* ANCHOLME GROUP Kellaways Fm. GREAT OOLITE GROUP Cornbrash Fm.	Excellent exposures of the Upper Thames 1st Terrace gravels and sands, deposited in late Pleistocene cold phase (mid-late Devensian), overlying Cornbrash Formation in part of the main pit and the Kellaways Clay Member in other parts. These strata are rarely exposed long-term and when available for study are of much potential educational value.
Soundborough Quarry	SP 052 215	RIGS	GREAT OOLITE GROUP Hampen Fm. Taynton Limestone Fm.	The quarry displays a near complete section through the Great Oolite Group, Taynton Limestone Formation (including upper contact) and basal part of the overlying Hampen Formation. This is a better exposure than the nearby Hampen Railway Cutting SSSI (now heavily overgrown) and Slade Quarry, Salperton (site now lost). Lithology: Hampen Fm; marls with discontinuous intraclasts. Taynton Limestone Fm; chamosite ooidal basal lag, sandy oolitic limestones and subordinate marls. Structurally, the beds appear near-horizontal with no significant faulting. Basal section of the Taynton Limestone shows typical medium-scale cross-stratification. The contact between the Taynton and Hampen Formations is cleanly exposed. Common oysters (*Praeexogyra hebridica*); common pelecypods, occasional brachiopods, rare crab claws and locally common wood fragments.
South Cerney Railway Cutting (Siddington)	SU 045 980	RIGS	ANCHOLME GROUP Oxford Clay Fm. *(Peterborough Mb.)* Kellaways Fm. *(Kellaways Sand Mb.,* *(Kellaways Clay Mb.)*	Disused railway cutting, well documented due to the rich ammonite fauna and great thickness of the Kellaways Formation once exposed here. Exposed is the Oxford Clay Formation (Peterborough Member), overlying the Kellaways Formation, both the clay and sand members of Kellaways Formation are exposed. This section represents one of only a few examples of the Kellaways Formation permanently exposed in the county. Page (1989) designated the cutting as the boundary stratotype for the *Galilaeii* Subzone (*Herveyi* Zone) of the Lower Callovian, with the section being “the best available in the area”. According to Arkell (1933), the cutting exposes the thickest development of “Kellaways Rock” (sand member) in the south west of England. Also exposed, above the Kellaways beds is the contact with the lower part of the Oxford Clay Formation, this contact is not known to be exposed anywhere else in the county. The faces exposed are very overgrown and highly weathered.
Spratsgate Lane Sand & Gravel Pit	SU 025 958	Local	Upper Thames Valley Fm. *(Northmoor Mb.)* ANCHOLME GROUP Kellaways Fm. *(Kellaways Clay Mb.)*	Excellent exposure of c.8 m of River Churn 1st Terrace deposits (corresponding to Northmoor Member 1st Terrace deposits), overlying Kellaways Formation (Kellaways Clay Member). The deposits consist of sands and gravels, locally derived from Middle Jurassic limestones, modified by post-depositional cryoturbation and solifluction. The lithology is predominantly of gravels with sands, the gravels are poorly-sorted, rounded to well-rounded, platy and tabular, and ranging in size from fines to large pebbles, with some rare flints and cobbles. The base of the quarry is in the Kellaways Clay Member, and comprises clay with thin sand bands. The basal section of the Northmoor Member comprises c.1-1.5m of medium to coarse-grained sands, interbedded with gravels, passing up into 7-8 of gravels with sands. Evidence of cryoturbation, solifluction and imbrication structures and graded bedding (fining up sequences). A very limited fauna was recorded (Inferior Oolite Group bivalves/brachiopods).
Standish Quarry	SO 823 075	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Formation *(Crickley Mb., Leckhampton Mb.)*	Exposed are lower members of the Birdlip Limestone Formation. The sequence exhibits good exposure of the Scissum Beds (Leckhampton Member) faulted up against the Lower Limestone (Crickley Member). Lithologies of oolitic and bioclastic limestones, few whole macrofossils seen, fragmented bivalves and brachiopods. Apparent dip of bedding c.30° west, the section is cambered due to proximity to the scarp. Minor faulting in northeast end of quarry, southeast end shows normal fault with Scissum Beds faulted up against the Lower Limestone, downthrow approximately 3m.

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Stanley's Quarry	SP 151 363	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Cleeve Cloud Mb.)*	The site is towards the north-eastern outcrop limit for rocks of this formation and immediately west of the Vale of Moreton axis. Exposed is a section through the Cleeve Cloud Member (Lower Freestone). Lower beds display cross-bedded, iron-stained oolites, upper beds are lime-stained with some calcarenite content, persistent clay bed, possibly the local equivalent of the 'rubbly ferruginous bed' (Richardson 1929 p.65) as described at Westington Hill Quarry. The beds appear almost horizontal; two areas of solution pipes can be seen in the south of the quarry, both are filled with dark brown soils. A limited brachiopod fauna observed.
Stonehouse Brick and Tile Co. & Jeffries Pits	SO 810 054	RIGS	LIAS GROUP Marlstone Rock Fm. Dyrham Fm. Charmouth Mudstone Fm.	Over 20 m of Lias clays, limestones & sandstone exposed. Reference Section For Dyrham & Marlstone Rock Formations. The sequence at this site is of considerable scientific interest, showing the junction between the Lower and Middle Lias. The rocks consist of clays belonging to the *Davoei* Zone at the top of the Lower Lias, succeeded by clays of the *Margaritatus* Zone of the Middle Lias, capped with the hard Marlstone Rock Formation (Spinatum Zone). These rocks are fossiliferous and enable the change in fauna at the junction to be studied. By careful comparison of the limestone bands here, with similar bands at Robinswood Hill, a non-sequence at the base of the Marlstone is shown.
Stoney Furlong Railway Cutting	SP 063 106	SSSI GCR	GREAT OOLITE GROUP White Limestone Fm. *(Ardley Mb., Shipton Mb.)* Hampen Fm.	Cutting on the disused Andoversford to Cirencester railway line, exposes an important section through the middle and lower part of the White Limestone Formation (Ardley and Shipton Members) and the now obscured underlying Hampen Formation. The section was first described by Harker (1892) during its construction and then later by Richardson (1911b). Richardson described some 26m of strata above the Hampen Formation, the basal section of the Shipton Member is no longer exposed. The top of this member is notable for yielding specimens of the ammonite *Morrisiceras*, confirming a Mid-Bathonian age (*Moruisi* Zone) of this part of the section. The highest strata now exposed are cross-bedded oolites, typical of the upper part of the Ardley Member in the Chedworth area. Within the sequence are a number of planed and oyster-encrusted hard grounds and a number of fossiliferous beds, yielding extensive faunas including gastropods, bivalves, brachiopods, echinoids and corals.
Stubbs Farm Sand & Gravel Pit (Barden Gravel Pit)	SU 170970	RIGS	Upper Thames Valley Fm. *(Northmoor Mb.)* ANCHOLME GROUP Oxford Clay Fm.	A large working quarry, exposing c.6 m of Quaternary river terrace deposits of the Northmoor Member (1st terrace deposits) overlying the Oxford Clay Formation. The gravels are poorly sorted, mainly flattened limestone pebbles between 10-50 mm diameter, with rare flints and some fine sand.
Swift's Hill Quarry	SO 878 068	SSSI GCR	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Upper Trigonia Grit Mb.)* Gryphite Grit Mb. Lower Trigonia grit Mb. Scottsquar Mb.	The site exposes a section of the middle part of the Inferior Oolite Group. The Birdlip Limestone Formation (Oolite Marl) and the base of the Aston Limestone Formation (Lower Trigonia Grit) are not well exposed here, although well exposed is the Gryphite Grit Member and the basal section of the overlying Salperton Limestone Formation (Upper Trigonia Grit Member). The Lower Trigonia Grit comprises "iron-shot" limestones and marls, yielding an extensive fauna of *Discites* Zone ammonites. The Gryphite Grit Member comprises "ragstones", containing bivalves; *Gryphaea, Lobothyris buckmani*. The top of this Member is marked by a well-developed bored and encrusted hardground. Above this, the Upper Trigonia Grit Member comprises an ooidal packstone with lenses of highly fossiliferous rubbly limestone, containing *Terebratula globata, Rhactorhynchia subtetrahedra* and *Trigonia.* Combined with other sites in the area, it provides a representative section of the Inferior Oolite Group within the Painswick Syncline. Reference section for the Aston Limestone Formation, Lower Trigonia Grit Member and the Gryphite Grit Member.
Syreford Quarry	SP 025 205	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Scottsquar Mb.)*	Quarry exposing Inferior Oolite Group; Birdlip Limestone Formation, Scottsquar Member (Upper Freestone). Near-horizontally bedded.

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Tetbury Goods Yard Cutting	ST 893 932	RIGS	GREAT OOLITE GROUP Forest Marble Fm. *(Great Oolite Reef Bed (?))* Fuller's Earth Fm. (*Coppice Limestone, Athelstan Oolite.)*	A deep cutting, now forming the eastern wall of a car park in Tetbury. Exposed are c.15-20m of Mid to Upper Bathonian, Great Oolite Group strata. The contact between the Fuller's Earth Formation and possible Great Oolite Reef Bed and Forest Marble Formation are all exposed. The lithology and structure of some of the formations are not typical and the exposure offers the potential to study these local and regional variations. Of importance here is the Great Oolite Reef Bed section, outcrops of this are rare, especially in the north of the Malmesbury district. Lithologies include: Athelstan Oolite; oolitic limestone, pisolitic near the base, planar bedded, with irregular bored top surface. Coppice Limestone; not typical lithology, basal 60 cm consists of a fossiliferous rubbly limestone/marl, top 1m is hard fine oolitic limestone, with ooids supported in a hard calcite matrix. Reef Bed; shelly oolite, reef structures visible. Forest Marble Formation; shelly ooidal limestone, thinly bedded. A diverse fauna is recorded form the various beds.
The Quarry, Dursley	ST 735 994	RIGS	LIAS GROUP Marlstone Rock Fm.	The site is now all that remains of a once very large Marlstone quarry, now partially in-filled with building waste. Only the upper 5m are visible, Iron-stained sandy biomicrite, very fossiliferous, *Spinatum* Zone. Type Locality for *Gibbirhynchia micra*.
Thornhill Farm Pit	SP 180 000	RIGS	Upper Thames Valley Fm. *(Northmoor Mb.)* ANCHOLME GROUP Oxford Clay Fm.	Good exposure of Upper Thames Valley (Northmoor Member) 1st terrace sands and gravels deposited during Late Pleistocene cold phase, overlying Oxford Clay Formation. These strata are rarely exposed long-term and thus are of much potential educational value. Deposits derived from local Middle Jurassic limestones, abundant water worn Jurassic remanie fossils, possibility of cold phase vertebrate remains such as mammoth and reindeer, although none yet found.
Tuffley's Quarry	SO 930 155	SSSI GCR	INFERIOR OOLITE GROUP Salperton Limestone Fm. *Upper Trigonia Grit Mb.* Aston Limestone Fm. *(Gryphite Grit Mb., Lower Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Scottsquar Mb.)*	Part of the Crickley Hill SSSI, GCR. A valuable exposure of the Inferior Oolite Group, illustrating the progressive loss of section from the 'Cleeve Hill Syncline' westward towards the 'Birdlip Anticline'. Highly varied lithologies demonstrated: Scottsquar Mb.; oosparite, small-scale cross-bedding. Lower Trigonia Grit Mb; basal marl with oolite pebbles, chamosite ooidal-skeletal wackestone/packstone with irregular bored, encrusted hardground at top. Gryphite Grit Mb.; sandy skeletal packstone/grainstone, top oyster-encrusted hardground. Upper Trigonia Grit Mb.; bioclastic limestone, packstone/grainstone. Fossiliferous in parts including; *Aulacothyris meriani, Modiola sowerbyana, Terebratula buckmani, Terebratula crickleyensis, Rhynchonella angulina, Rhynchonella hampenensis, Acanthothyris spinosa.* The strata here are essentially horizontal, with a slight camber into the steep scarp slope, no significant faulting.
Veizey's Quarry	ST 881 944	SSSI GCR	GREAT OOLITE GROUP Forest Marble Fm. *(Coombe Down Oolite, Athelstan Oolite)*	The site shows a representative section through part of the Upper Bathonian succession, from the upper part of the Athelstan Oolite through to the overlying Forest Marble. Exposed is c.6.4 m of the Athelstan Oolite, a massive, thick-bedded, ooidal, and finely shell-detrital limestone, with clay flakes or pebbles in parts. The limestone bands are separated by thin clay partings. These beds have yielded bivalves, brachiopods, gastropods, echinoid, and wood fragments. This passes into fine-grained, gently cross-bedded oolites up to 0.6m thick, yielding fragmented epifaunal bivalves and gastropods. The top of the formation is capped by a bored hardground. Overlying the formation is the Coombe Down Oolite Member, an oolite, steeply planar cross-bedded in the lower part. This is overlain by the Forest Marble formation, a shelly, flaggy limestone, cross-bedded in part, with subordinate interbeds of clay containing thin partings of silty limestone. The basal limestone bed contains limestone pebbles and fish teeth. No fossils of diagnostic biostratigraphical value have been found here. The quarry is the best reference section displaying typical Athelstan Oolite development in the Tetbury district.

SITE NAME	GRID REF'	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Wagon Quarry (Salterley Grange Quarry	SO 946 177	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Cleeve Cloud Mb., Crickley Mb.)*	Within Leckhampton Hill SSSI, exposing approximately 18m of the Cleeve Cloud Member (Lower Freestone) overlying 0.50m of Crickley Member (Pea Grit) making up the quarry floor. At this location the top of the Crickley Member is represented by a vertically heavily bored hardground, evident in the western part of the quarry and the north-west face. The north-east and eastern face do not display the hardground but show an upward change from a coarse oolite at the base, containing small pisolith/peloids including shell fragments and crinoid ossicles, to a well sorted medium-grained oosparite. Dreghorn (1965, 1967) mentions a reverse fault caused by compression as a result of cambering. No clear evidence of this is seen but the apparent disappearance of the Crickley Member on the north and western faces and no hardground on the eastern face may be due to the effects of cambering to the west.
Waterworks Quarry	ST 767 943	RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Clypeus Grit Mb., Upper Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Cleeve Cloud Mb., Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm.	A fairly complete section from the Upper Lias to Inferior Oolite Group succession of the south Cotswolds, showing typical lithologies and rock types. A very useful section for comparison with other localities along the Cotswold edge. The main quarry exposes the Crickley and Cleeve Members (Birdlip Limestone Formation), overlain unconformably by the Upper Trigonia Grit Member (Salperton Limestone Formation). The section can be extended upwards into the Clypeus Grit member in a nearby smaller quarry and downwards through the Leckhampton Member and into the uppermost part of the Bridport Sands. Lithologies are variable including oolites, biomicrites, biosparites, sand with concretions and iron-rich marls. Many of the usual Bajocian fossil assemblages are found in the Upper Trigonia and Clypeus Grit members; typical fauna in the Cephalopod Bed and shell fragments in the Crickley Member. Structurally the sequence is slightly rotated, dipping north.
Wellacre Quarry (Blockley Station Quarry)	SP 180 370	SSSI GCR	LIAS GROUP Dyrham Fm. Charmouth Mudstone Fm.	Best and most complete exposure in Britain of part of Middle Lias rock succession (*Luridum* Subzone), well documented, with abundant fossil fauna, including a very important suite of ammonites. Specimens collected from this site have been subject of detailed research providing an important insight into ammonite evolution and physiology.
Wiggold Railway Cuttings (Stow Road Cuttings)	SP 044 051	RIGS	GREAT OOLITE GROUP Forest Marble Fm. White Limestone Fm. (incl. *Kemble Beds)*	The site comprises two disused railway cuttings on part of the Cotswold dip slope. Exposed is a continuous section through the White Limestone and Forest Marble Formations, not widely available in the Cotswolds. The site can be linked to the well-conserved Chedworth Cuttings to the north, providing a valuable geological section through much of the Cotswold Middle Jurassic rock sequence. The cutting rises to a maximum height of approximately 6m, exposing oolitic, shell-fragmental and mud-grade limestones, with minor marl seams, clay beds, the latter now obscured. Lithologies include: White Limestone Formation; medium-grained oolite, small shell fragments. Kemble beds; medium-coarse-grained oolite, shelly with local brown marls, the bed pinches out to the north. Forest Marble Formation; medium-coarse-grained, shelly oosparite, cross-bedded with some through cross-bedding. A variety of bivalves, brachiopods, and some echinoids observed. The top bed of the White Limestone Formation is particularly fossiliferous.
Winstones "Tropical Surprise"	SO 855 033	RIGS	INFERIOR OOLITE GROUP Salperton Limestone Fm. *Clypeus Grit Mb. [Upper Coral Bed], Upper Trigonia Grit Mb.)*	In close proximity to Montserrat Quarry in the Rodborough Common area and exposing various members of the Salperton Limestone Formation (Inferior Oolite Group), including the relatively rare 'Coral Bed'. The site is degrading due to scree build-up and vegetation cover. Exposed are the Upper Trigonia Grit Member and the overlying Upper Coral Bed and Clypeus Grit of the Clypeus Grit Member. The site yields numerous specimens of the Jurassic Scleractinian coral *Liastrea*, a colonial reef forming coral. These coral 'patch reef' sections are now poorly exposed.

SITE NAME	GRID REF’	SITE STATUS	STRATIGRAPHY REPRESENTED	SPECIFIC FEATURES
Woodchester Park Tufa Stream	SO 826 006	RIGS	Tufa GREAT OOLITE GROUP Fuller’s Earth Fm.	The site comprises a section of a narrow, shallow stream outcropping from the Fuller’s Earth Formation (possibly at the top of the Lower Fuller’s Earth Clay Member) approximately 200m above the main valley on the southern side of Woodchester Park. The stream flows ENE down a steep hillside with many small waterfalls along its length. It cuts through the Fuller’s Earth and Accuminata Beds which form localised slump deposits. Tufa deposition is active here, forming an exposure approximately 11m wide and at least 150m long along the streambed. Deposition is also active over a wider area (over 10m wide) lower down slope where the stream is shallower. Many tufa-encrusted leaf and wood fragments are visible and thick tufaceous sediments fill the streambed and surrounding area. Other streams on the southern side of the valley also demonstrate tufa formation along their length.
Woodchester Park Container Quarry	SO 826 013	RIGS	INFERIOR OOLITE GROUP Birdlip Limestone Fm. *(Crickley Mb.)* LIAS GROUP Bridport Sand Fm.	This cutting exhibits a rare exposure of the Cephalopod Bed (Bridport Sand Formation) at the top of the Lias Group. Zonal ammonites obtained from the section indicate that the *Grammoceras thouarsense* zone within the Lower Jurassic, Upper Toarcian substage are exposed here. The Cephalopod Bed also contains concretionary nodular ferruginous sandstone and marls, overlying the Bridport Sand Formation. The section is capped by c.1m of slumped, rubbly limestone, probably derived from the overlying Lower Freestone (Crickley Member).
Wotton Hill Quarries	ST 753 942	SSSI GCR	INFERIOR OOLITE GROUP Salperton Limestone Fm. *(Upper Trigonia Grit Mb.)* Birdlip Limestone Fm. *(Crickley Mb., Leckhampton Mb.)* LIAS GROUP Bridport Sand Fm.	The site comprises two quarries, the lower quarry (Old London Road) and the upper quarry. The lower quarry exposes an excellent section through the top of the Lias Group, Bridport Sand Formation (Cotteswold Sands) which is unfossiliferous here, overlain by the Cephalopod Bed. This locality is a reference section for the Bridport Sand Formation. This bed yields common belemnites and occasional ammonites of *Striatulum* to *Aalensis* Zone age. The Cephalopod bed here is relatively thick and complete, the top of the bed is marked by a remanie horizon of probable *Aalensis* zone age, characterised by abundant ammonites, coated intraclasts and ironshot *Thalassinoides* burrows. The Cephalopod Bed is abruptly overlain by the Scissum Beds (Leckhampton Member), marking the Lower Middle Jurassic boundary, which in turn is overlain by the Lower Limestone (Crickley Member). The contact between these two beds is obscured. The succession continues in the upper quarry with the Lower Limestone, showing cross-bedding. The overlying Lower Freestone (Crickley Member) yields pelecypod debris, bryozoa, serpulids and gastropods, with crinoid ossicles, echinoid plates, coral fragments and rare quartz pebbles. The Lower Freestone is in turn overlain unconformably by the Upper Trigonia Grit Member, the contact between these two beds is heavily bored. This basal disconformity represents a considerable non-sequence, spanning approximately 6.71Ma. The uppermost part of the quarry poorly and unconformably exposes beds representing the Upper Coral Bed, yielding very rare ammonites, including *Lissoceras psilodiscum*.

SECTION 4

IMPLEMENTING THE ACTION PLAN & INTERPRETING GEODIVERSITY

SECTION 4 IMPLEMENTING THE ACTION PLAN & INTERPRETING GEODIVERSITY

4.00 Implementation of the Gloucestershire Cotswolds LGAP

The potential success of the Cotswolds Local Geodiversity Action Plan is closely linked with the existence of channels through which the future geoconservation recommendations, as outlined in the plan, can be actioned. This ultimately is dependent on two things, the various groups, authorities and associations within the Cotswolds who may be willing to become involved in this initiative, working either as a network or independently and the effectiveness of an ongoing steering group to ensure that progress is maintained. It is envisaged that the steering group will consist of some or all of the groups identified in the table as falling into the "advisory" category.

A review of how the recommendations may be put into action has been undertaken to identify groups with the necessary available resources. This information is summarised in Table 4.01 The list of groups mentioned is by no means exhaustive and it is hoped that this will be increased and updated as the action plan is implemented.

4.01 Potential Resources

The nature of the potential resources have been categorised into the following groups:

i. *Advisory*

In order that high standards of working practise are maintained during the implementation of recommendations, it is essential that communication is developed and preserved with all relevant advisory bodies. These bodies include all those with influence and involvement in areas of the Cotswolds at which geological interest is present.

ii. *Educational*

Groups identified as having the potential resources in this category include those with the facility to host educational events linked with geodiversity such as museums and schools.
Also included are local authorities, parish councils, quarry operators and land owners who may be able to facilitate the locating of interpretation boards to further public awareness of geodiversity.
Local environmental and conservation groups are also an important channel in this category in facilitating the organisation of guided walks and talks.

iii. *Geoconservation*

This category refers to groups that can specifically help in the organisation of geoconservation work and the resourcing of manpower required to carry out that work. The Parish Councils within the Cotswolds have the potential to become involved at this level by involving communities in the vicinity of a geological site.

iv. *Reference*

An essential part of enhancing and preserving the geodiversity in the Cotswolds is the research that must be undertaken prior to any initiatives being developed. This includes collating specific information about geological sites (e.g. the landowner, history of the site, any restrictions applicable to that site, permissions that may be required to carry out geoconservation work or siting of interpretation boards etc.) Groups able to help with the provision of this information include local authorities, local history groups,

v. *Promotional*

The dissemination of information contained in the Cotswolds LGAP itself and subsequent communication of progress made needs to be channelled through as many outlets as possible in order to maximise the size of audience reached. This can be resourced by using several methods of publicity. Groups have been identified in the table if they have the facility to include information on a website, or links to the main website at Gloucestershire Geoconservation Trust and those who may be willing to include information in a newsletter. Resources for publishing details of geological events and updates relating to the LGAP will be resourced using contacts with the local media outlets.

GROUPS		SPECIFIC RESOURCES POTENTIALLY AVAILABLE	AREA TO WHICH SPECIFIC SKILLS CAN POTENTIALLY BE APPLIED				
			Advisory	Education	Geoconservation Work	Reference	Promotion

Tale 4.01

Environmental/Conservation - Local							
	Gloucestershire Geoconservation Trust	Geological expertise	X	X	X	X	X
	English Nature		X		X	X	X
	Cotswold AONB Partnership		X	X		X	X
	The Geology Trusts		X	X			X
	Cotteswold Naturalists' Field Club			X		X	
	Wildfowl & Wetlands Trust			X			X
	Gloucestershire Wildlife Trust			X			X
	British Trust for Conservation Volunteers	Volunteer manpower			X		
	Stroud Valleys Project			X			X
	Westonbirt Arboretum			X			X
	National Trust Gloucestershire		X			X	
	The Woodland Trust South West		X			X	
	Gloucestershire Society for Industrial Archaeology			X		X	
	Woodchester Mansion Trust			X			X

GROUPS	SPECIFIC RESOURCES POTENTIALLY AVAILABLE	AREA TO WHICH SPECIFIC SKILLS CAN POTENTIALLY BE APPLIED				
		Advisory	**Education**	**Geoconservation Work**	**Reference**	**Promotion**

Table 4.02

Local groups						
Friends of Leckhampton Hill		X	X			
Cleeve Common Conservators		X	X			
Stinchcombe Hill Conservation Group		X	X			

Table 4.03

Authorities						
Gloucestershire County Council	Advice, information, links to planning strategies	X			X	X
Cotswold District Council	..	X			X	X
Tewkesbury Borough Council	..	X			X	X
Cheltenham Borough Council	..	X			X	X
Stroud District Council	..	X			X	X

Table 4.04

Parish Councils						
Selsley Parish Council		X		X		

GROUPS		SPECIFIC RESOURCES POTENTIALLY AVAILABLE	AREA TO WHICH SPECIFIC SKILLS CAN POTENTIALLY BE APPLIED				
			Advisory	**Education**	**Geoconservation Work**	**Reference**	**Promotion**

Table 4.05

Quarry Operators							
	Huntsman's Quarries Ltd.	Educational outlet for interpretation		X	X		
	Cotswold Stone Quarries Ltd.	..		X			
	Farmington Natural Stone Ltd.	..		X			
	Natural Stone Market Ltd.	..		X			
	Hanson Aggregates Ltd.	..		X			X
	Soundborough Quarries Ltd.			X			
	Goldhill Quarry			X			
	Tetbury Stone Co. Ltd.			X			

Table 4.06

Academic Institutions							
	University of Gloucestershire	Geological, geomorphological information	X			X	
	Royal Agricultural College Cirencester	Soils				X	

GROUPS		SPECIFIC RESOURCES POTENTIALLY AVAILABLE	AREA TO WHICH SPECIFIC SKILLS CAN POTENTIALLY BE APPLIED				
			Advisory	Education	Geoconservation Work	Reference	Promotion

Table 4.07

Museums							
	The Museum in the Park, Stroud	Venue for public events, location for displays		X			X
	Cheltenham Museum & Art Gallery	..		X			X
	Corinium Museum, Cirencester	..		X			X

Table 4.08

Corporate Bodies							
	I.H.S. Energy (Tetbury)		X			X	
	Oolithica		X			X	

GROUPS		SPECIFIC RESOURCES POTENTIALLY AVAILABLE	AREA TO WHICH SPECIFIC SKILLS CAN POTENTIALLY BE APPLIED				
			Advisory	Education	Geoconservation Work	Reference	Promotion

Table 4.09

Regional Associations							
	Quarry Products Association (South West)	Advice, links with local quarry operators, educational outlet	X	X			
	South West Regional Development Agency	Links to tourist industry					X
	West of England Geologists' Association	Geological expertise				X	
	Farming Wildlife Advisory Group South West	Links to local farmers	X				
	The National Trust Gloucestershire	Advice, information on landownership	X	X		X	

GROUPS	SPECIFIC RESOURCES POTENTIALLY AVAILABLE	AREA TO WHICH SPECIFIC SKILLS CAN POTENTIALLY BE APPLIED				
		Advisory	**Education**	**Geoconservation Work**	**Reference**	**Promotion**

Table 4.10

National Groups						
The National Trust		X	X			
Joint Nature Conservancy Council		X			X	
The Geological Society		X			X	X
The Geologists' Association		X			X	X
British Geological Survey		X			X	X
Forestry Commission		X				
Farming & Wildlife Advisory Group		X				
Campaign to Protect Rural England		X				
UK RIGS		X				X
The Woodland Trust		X	X			
Country Landowners Association	Advice, links to landowners	X				X

GROUPS		SPECIFIC RESOURCES POTENTIALLY AVAILABLE	AREA TO WHICH SPECIFIC SKILLS CAN POTENTIALLY BE APPLIED				
			Advisory	Education	Geoconservation Work	Reference	Promotion

Table 4.11

Media							
	Radio Gloucestershire						X
	Cotswold Life Magazine						X
	Severn Sound						X
	Citizen Newspaper						X
	Gloucester Echo						X
	Gazette Newspapers						X
	Down to Earth Publication						X

a. Sites

The sample selection of sites named below have been chosen for their value to maintaining and improving geodiversity across the Gloucestershire Cotswolds. Sites have been named for both their scientific and educational importance to demonstrating the stratigraphic succession, palaeontology, palaeoenvironments and structure; and for their importance to both static and active geomorphological processes. Those sites showing boundaries between different stratigraphical units above and below will be the most valuable. Some sites are currently in a good condition and geoconservation required at these will be ongoing management and retention of currently visible features of interest. Other sites are in worse condition and will require more extensive geoconservation work in order to re-expose the features of interest and to improve safety, access and interpretation.

Table 4.12; Key Sites

Site Name	Features of Interest	Value
Shorncote Quarry	First (Northmoor) Terrace of River Thames and tributaries. Cornbrash, Kellaways Clay and Forest Marble.	Periglacial sedimentology; stratigraphy; palaeontology.
Veizey's Quarry	Athelstan Oolite & Forest Marble (Dagham Stone)	Stratigraphy; palaeo-environments.
Stoney Furlong Cutting	White Limestone (Shipton Member)	Stratigraphy; palaeontology.
Minchinhampton Common Quarries	Fullers Earth-Great Oolite Ammonite type-specimens *Tulites subcontractus & Morrisiceras morrisi*; gastropods incl. *Purpuroidea.*	Stratigraphy; palaeontology.
Hampen Cutting	Fullers Earth; Hampen Marly Formation; White Limestone	Stratigraphy; palaeo-environments.
Hornsleasow Quarry	Vertebrate palaeontology in palaeokarst clay bed within Chipping Norton Limestone. Sharpshill Formation, Taynton Limestone.	Stratigraphy; palaeontology; palaeo-environments.
Cleeve Common	Inferior Oolite Group; full stratigraphic sequence including a unique exposure of the Rolling Bank Member	Stratigraphy; palaeo-environments.
Leckhampton Hill	Inferior Oolite Group: thickest inland sequence including important unconformities/attenuations of strata.	Stratigraphy; palaeo-environments.
Wotton Hill	Bridport Sand Formation incl. Cephalopod Bed.	Palaeontology; palaeo-environments.
Haresfield Beacon	Base of Birdlip Limestone Formation. Excellent landscape views.	Landscape; Stratigraphy.
Wellacre Quarry / Blockley Brickpit	A rare Dyrham Formation (Middle Lias) *Luridum* subzone exposure containing an important suite of ammonite fauna.	Stratigraphy; palaeontology.
Postlip Warren	The best example of 'ridge and trough' features in Britain (EN SSSI notification, 1987).	Quaternary geomorphology.

b. Features

In addition there are certain features/formations that are not currently exposed or are poorly exposed that are needed to complete a full account of the geodiversity of the Gloucestershire Cotswolds. References to potential sites come from fieldwork and past literature. The database at the Gloucestershire Geological Records Centre holds data on potential sites, so far unsurveyed, which could improve and advance the available geodiversity of the area. The table below (Table 4.13) gives examples of some geological units currently under-represented and potential sites where they could be exposed.

Table 4.13; Key Features

Feature / Unit	Potential Site(s)	Comment
Lower Fuller's Earth Clay & Acuminata Beds	An old, overgrown quarry beside the B4066 Stroud-Uley Road at	Due to the soft nature of the clays, exposures in the Fullers Earth are difficult to maintain. However it is an important unit both geologically and historically and efforts should be made to create a sustainable exposure.
Cephalopod Bed	Cud Hill Quarry, Upton St Leonards.	The Cephalopod Bed is exposed in the south of the area around Stroud and, in its condensed form, in the north at Cleeve and Leckhampton Hills but correlation in the mid-Cotswolds is missing.
Marlstone Rock Bed	Cotswold Escarpment; Vale of Moreton; Vale of Bourton	The MRB is an important landscape forming bed but is infrequently exposed although the flat ledge it forms easily distinguishes its location.
Harford Member	The Holt Quarry, Nr. Bourton-on-the-Hill SP 148353: Buckholt Wood, Nr. Cranham SO 894131	The Harford Member is cut out by unconformities in some parts of the area and a number of sites in this member would aid interpretation of past environments.
Rolling Bank Member	Pegglesworth area, SW of Cheltenham SO 990180	The Rolling Bank Member is currently only exposed in Rolling Bank Quarry on Cleeve Hill. Another exposure in this member would greatly aid interpretation of this member in the area.

Cleeve Common

Cleeve Common has SSSI status afforded to its outstanding geological and geomorphological interest as well as the limestone grassland value of the Common. It also contains many other sites of great importance to the geology of Gloucestershire.

The principal geological potential on Cleeve Common lies in the sections that are exposed in the many small pits and quarries that lie all over and around the common. Cleeve Common lies in the axis of the thickest sequence of Lower and Middle Inferior Oolite sediments in the Cotswolds. It is not only unique in exposing potential outcrops of strata that are found nowhere else in the Cotswolds but also in being the only area in the Cotswolds where the full sequence of Inferior Oolite rocks can be seen. Important structures in the sequence include excellent exposures of downlap and giant forests at the base of the Lower Freestone and probable large scale channelling at the top (Toland, 2002). It cannot be emphasised enough that Cleeve Common has a very special and unique geological potential that was almost totally hidden due to the neglect of the last 90 or so years.

Cleeve Common: numerous quarries and pits of high geodiversity importance.

Leckhampton Hill

The disused quarries on Leckhampton Hill and Charlton Kings Common expose an almost complete sequence of the Cotswold Middle Jurassic, Inferior Oolite rocks plus the uppermost part of the underlying Early Jurassic Lias Group. All aspects of the geology can be seen easily and safely seen in numerous disused quarries that are all part of the SSSI.

The principal interest on Leckhampton Hill is the relative thickness of the strata and completeness of the lower part of the sequence from the Whitby Mudstone Formation of the Lias Group to the Lower Trigonia Grit towards the top of the Inferior Oolite Group. The Cotswold Sands (Bridport Sand) facies is largely absent and the Upper Lias Cephalopod Bed and the Inferior Oolite Lower Limestone is highly attenuated. The Scissum Beds (Leckhampton Member) are thicker here than in the southern Cotswolds and include a basal argillaceous member but the Pea Grit (Crickley Member) is thinner than at nearby Crickley Hill (Toland, 2002).

The succession includes such features as large-scale cross-bedding, channelling in the Upper Freestone (Scottsquar Member) (Toland, 2002) and hardgrounds with bored and encrusted surfaces and post-depositional structures including faults and cambering. One of the most recognisable features of the Cotswold Escarpment is the Devil's Chimney, a folly left behind by quarrymen, which can be seen near to Deadmans Quarry. The remains of early 20th century limekilns can be seen as well as remnants of tramways and roads that were used to transport quarried material away from the site.

Devil's Chimney, Leckhampton Hill: one of the most noticable and best known geodiversity features in the Gloucestershire Cotswolds

Crickley Hill

Crickley Hill is an important area for geological, archaeological and biological features of interest. The cliffs of Crickley Hill provide the finest and thickest exposure of Pea Grit in the region and the hillfort offers splendid views across the Severn Vale. The Pea Grit (Crickley Member) contains an important exposure of the Crickley Coral Bed and a unique occurrence of soft calcitic ooids can be found in the Lower Limestone (Cleeve Cloud Member). Crickley Hill has one of the best documented micropalaeontological profiles in the area (Toland, 2002) due to the long history of geological study here.

Much of the area is a SSSI for its biological interest or Scheduled Ancient monument (SAM) for its archaeological interest as well as its important geology. Numerous springs emerge from the hillside where the permeable Inferior Oolite rocks meet the underlying impermeable Lias Group.

The escarpment from Crickley Hill: The thickest and best exposed development of the "Pea Grit Facies" in the Cotswolds.

Rodborough Common: few exposures remain available at this internationally important site.

Vale of Moreton

Superficial deposits dating from the Quaternary and Recent are extensively distributed over the lower lying areas of the Cotswolds and in the valleys that cut into the hills. Ice from early glaciations entered the Vale of Moreton (Goudie & Parker, 1996) but evidence of a direct impact of glaciation elsewhere in the Cotswolds is very limited.

Deposits include fluvial and glacio-fluvial sands and gravels (from which numerous vertebrate remains have been recovered); gravels derived from local Jurassic limestone; boulder clay (Moreton Drift) left behind by a retreating glacier and more recent alluvial deposits. A thin layer of red clay between the Paxford Gravels and the overlying Moreton Drift has been interpreted as a remnant deposit of glacial Lake Harrison which covered the area to the north-east. Several cols in the escarpment have been interpreted as outflow channels from this lake (Goudie & Parker, 1996).

Stroud, Minchinhampton & Rodborough Commons.

The steep sided valleys and elevated commons around Stroud provide an excellent opportunity to study the geology and to collect specimens from the highly fossiliferous layers in this area. Even as early as 1882, Witchell, says that "The principal rock sections have long attracted the attention of the most eminent geologists and have become typical of the strata they represent", and that is still true today. Some of the most remarkable finds in Cotswold, and international, palaeontology have come from the are including the ***Megalosaurus*** skull/ jaw from Minchinhampton that is now in the Natural History Museum.

The valleys and the occurrence of Fullers Earth capped by Great Oolite limestones along the valley sides has led to an extensive system of landslips, valley bulging and cambering that may be the highest concentration of mass movement processes in England.

Wotton Hill

Wotton Hill is also a SSSI and represents a relatively inshore setting during the time of deposition of the sediments The Birdlip Limestone Formation (Lower Inferior Oolite) is less than half the thickness here than it is further north in the Cotswolds and the top of the Lower Jurassic is represented by oolitic ironstones with reworked sediments and fossils capping the formation. The Scottsquar Member of the Birdlip Limestone Formation and the whole of the Aston Limestone Formation are absent through erosion or non-deposition meaning that the Lower Freestone (Cleeve Cloud Member) is directly overlain by Upper Trigonia Grit (Clypeus Grit Member (Toland, 2002).

Wotton Hill Quarry: in danger of becoming obscured by trees.

Windrush and Evenlode Valleys

The head of the River Windrush appears just south of Snowshill and quickly becomes confined within a steep sided valley with incised meanders. All along its length the river exhibits misfit stream form and valley in valley meanders indicative of much higher flow rates earlier in its development, almost certainly dating from the end of the last Ice Age around 10,000 years ago. These features are particularly well developed to the east of Naunton.

The Evenlode Valley is much wider than that of the Windrush and provides the most extensive deposits of recent alluvium in the area. Classic valley in valley meanders occur south of Moreton-in-Marsh and the “misfit” of the river within the valley can clearly be seen. Smaller misfit streams and dry valleys lead into the Evenlode Valley and again provide evidence for long term climatic change.

Two Views of the River Windrush: Right - flowing through Naunton village; Below - as a misfit stream passing through an oversized valley (the river is flowing along the line of trees to the right of the photograph).

There are over 3000 miles of public footpaths in the Cotswolds and walking is one of the best ways in which to enjoy and appreciate the unique character of the area. There are a mixture of long and short distance routes that wind through the attractive stone villages, rolling hills and river valleys. The Ramblers Association is a good source of information on walks through the Cotswolds (www.ramblers.org.uk).

Examples of some of the major footpaths routes in the Cotswolds are:

The Cotswold Way
Stretching over 100 miles from Chipping Campden to Bath The Cotswold Way is one of the great long distance trails in the country and has recently been upgraded to have national status. Following the escarpment, it gives way to stunning views of not only the Cotswold Hills themselves, but also the Severn Vale and into the Welsh border counties. Sections of the escarpment itself display the largest exposure of Jurassic rock in the country and there are a number of excellent sites along the way, such as those found on Cleeve Common and Leckhampton Hill. Leaflets and guides are available from various outlets such as tourist information centres, museums and visitor centres.
Other walks include :

The Gloucestershire Way
Again stretching around 100 miles from Chepstow to Tewkesbury the route takes you through both the Cotswolds and the Forest of Dean. It crosses the Severn at Gloucester and leads into the heart of the Cotswolds finally doubling back into Winchcombe.

The Wardens' Way and Windrush Way
These routes link with the Oxfordshire Way, both starting in Winchcombe and ending in Bourton-on-the-Water. The Wardens' Way winds through the villages of Guiting Power, Naunton and both Upper and Lower Slaughter.
It is complimented by the Windrush Way that travels over the hills visiting lost medieval villages en route to the River Windrush at Bourton.

The Wysis Way
This route in Gloucestershire takes you in total 55 miles through the Forest of Dean, Severn Vale and the Cotswolds, linking the Rivers Wye, Severn, Thames and the two National Trails Offa's Dyke Path and the Thames Path.

The Macmillan Way
A newly opened route stretching 290 miles from Dorset to Lincolnshire which crosses part of the Cotswolds, entering south of Tetbury it follows a north-easterly direction through Stow-on-the-Wold.

The Monarchs Way
Following the route that Charles II took during his escape after the Battle of Worcester in 1651 this path covers a section of the Cotswolds but also passes through the Mendips, onto the South Coast and finally to the South Downs. This route is a staggering 610 miles in length.

Cycle Paths

There are a number of cycle routes around the Cotswolds, the best way of finding these are through the National Cycle Network website (www.sustrans.org.uk). Pocket and foldout maps of cycle routes are also available from Tourist Information Centres, selected shops and museums. Gradually small wooden signs are being installed onto signposts at junctions to help navigate.

Bridleways

The Cotswolds is an ideal location for anyone with an interest in horse related activities. Numerous riding centres cater for both the experienced and novice rider and take advantage of the many miles of public bridleways found in the Cotswolds. These paths like the footpaths and cycle routes have the benefit of passing through areas with outstanding geological sites and landscapes. Again some of the major paths are located on Cleeve Common and Leckhampton Hill both of which form part of the escarpment.

4.05 Guided Walks & Field Trips

A number of groups and organisations operating within the Gloucestershire Cotswolds organise a variety of walks and field meetings, many if not all of which include elements of geodiversity in their attractions. A sample of some of the organisations that regularly lead walks and field meeting in the Cotswolds is given below, although there are many others. Local Tourist Information Centres can provide further details of walks and events throughout the year.

It is intended, through the adoption of this plan, to establish a regular programme of geological and landscape themed walks and field trips in order to further interpret and raise awareness of the great diversity of geological features and landforms in the area.

Gloucestershire Geoconservation Trust

GGT have published a series of guided trails entitled ‘Gloucestershire Uncovered’ looking primarily at geology and landscape but which also include information on related matters of historical, archaeological and biological interest. At present three trails are published for the Cotswold area but others are planned for release in the near future. The three current trail guides are Cleeve Common, Leckhampton Hill and Crickley Hill.
Contact: Gloucestershire Geoconservation Trust, 01452 864438, info@glosgeotrust.org.uk

Cotswolds AONB

The programme guide comprises walks and events throughout the Cotswolds. The walks are mainly led by the Cotswold Voluntary Wardens and the events are run by a variety of other organisations such as National Trust, Gloucestershire County Council, Gloucestershire Geoconservation Trust and Gloucestershire Wildlife Trust.
Contact: Cotswolds AONB, 01451 862000
(www.cotswoldsaonb.com)

Cotswolds Tourist Guides

The Cotswolds Guides provide guides for regular summer coach and walking tours organised by Cheltenham Tourist Office and other tour operators. Tours and country walks can follow established formats or be tailored to suit a groups requirements and interests.
Contact: Cotswold Guides, 01242 226033,
info@cotswoldguides.org.uk

Gloucestershire Wildlife Trust

The Wildlife Trust lead various walks on their reserves and other parts of the Cotswolds looking at all aspects of nature and wildlife.
Contact: Gloucestershire Wildlife Trust, 01452 383333,
info@gloucestershirewildlifetrust.co.uk

The Ramblers Association

There are eight regional groups of ramblers that cover different parts of Gloucestershire. They lead a variety of walks each weekend and two weekday walks each month.
Contact: Gloucester Ramblers Group, 01452 864451, www.ramblers.co.uk

The National Trust (Wessex Region)

Gloucestershire is part of the Wessex Regional National Trust and contains numerous properties, commons and country parks where they run regular walks and workshops.
Contact: 01985 843600, enquiries@thenationaltrust.org.uk

Stroud Valleys Project

The Stroud Valleys Project runs a varied programme of activities from carrying out conservation work to wildlife watching days. One of their most popular activities is a regular fossil hunt, led by geologists from Gloucestershire Geoconservation Trust.
Contact: 01453 753358, info@stroudvalleysproject.org

Abbreviations used in this document:

ALSF	Aggregates Levy Sustainability Fund
AONB	Area of Outstanding Natural Beauty
AONB-SDF	Area of Outstanding Natural Beauty – Sustainable Development Fund
BGS	British Geological Survey
BRERC	Bristol Regional Environmental Records Centre
CNFC	Cotteswold Naturalists Field Club
EH	English Heritage
EN	English Nature
GCER	Gloucestershire Centre for Environmental Records
GCR	Geological Conservation Review
GGRC	Gloucestershire Geological Records Centre
GGT	Gloucestershire Geoconservation Trust
GT	Geology Trusts
HLF	Heritage Lottery Fund
LBAP	Local Biodiversity Action Plan
LGAP	Local Geodiversity Action Plan
LTCS	Landfill Tax Credit Scheme
MIRO	Mineral Industry Research Organisation
RIGS	Regionally important Geological / Geomorphological Site
SSSI	Site of Special Scientific Interest
UKGAP	United Kingdom Geodiversity Action Plan

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SECTION 5

GLOUCESTERSHIRE COTSWOLDS LOCAL GEODIVERSITY ACTION PLAN

Acknowledgements:

The Gloucestershire Cotswolds LGAP Partnership wishes to express its thanks to the many individuals and organisations that have contributed in many ways to the production of this Geodiversity Audit and Local Geodiversity Action Plan.

Cheltenham Borough Council

Chris Toland, Oolithica Geoscience

Cotswold District Council

Cotswolds AONB Conservation Board

Cotteswold Naturalists Field Club

Country Landowners Association (CLA)

Daglingworth Quarry

Dr Nick Chidlaw

English Heritage

English Nature

Farming and Rural Conservation Agency (FRCA)

Farming and Wildlife Advisory Group (FWAG)

Farmington Natural Stone Ltd

Gloucestershire County Council

Gloucestershire Environmental Records Centre

Gloucestershire Society for Industrial Archaeology

Gloucestershire Tourism

Gloucestershire Wildlife Trust

Herefordshire & Worcestershire Earth Heritage Trust

Huntsmans Quarries

IHS Energy Ltd.

Impressions of Monmouth Ltd.

Mineral Planning Dept, Gloucestershire County Council

National Farmers Union

National Trust

Ramblers Association

Stroud District Council

Tewkesbury Borough Council

The Geology Trusts

United Utilities

Wildfowl & Wetlands Trust

For more information on the Gloucestershire Cotswolds Geodiversity Audit and Local Geodiversity Action Plan, contact:

Gloucestershire Geoconservation Trust
The Geological Records Centre
The Tithe Barn Centre
Brockworth
Gloucestershire
GL3 4QU

Tel: 01452 864438
E-mail: info@glosgeotrust.org.uk

Web: www.glosgeotrust.org.uk

www.miro.co.uk
www.glosgeotrust.org.uk
www.cotswoldsaonb.com
www.ihsenergy.com