The Geological Heritage of Kilkenny

By Aaron Clarke, Matthew Parkes
and Sarah Gatley

December 2007

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Kilkenny Heritage Forum

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An audit of County Geological Sites in Kilkenny

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December 2007

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Kilkenny Heritage Forum

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Report Summary
(County Geological Sites in the Planning Process)

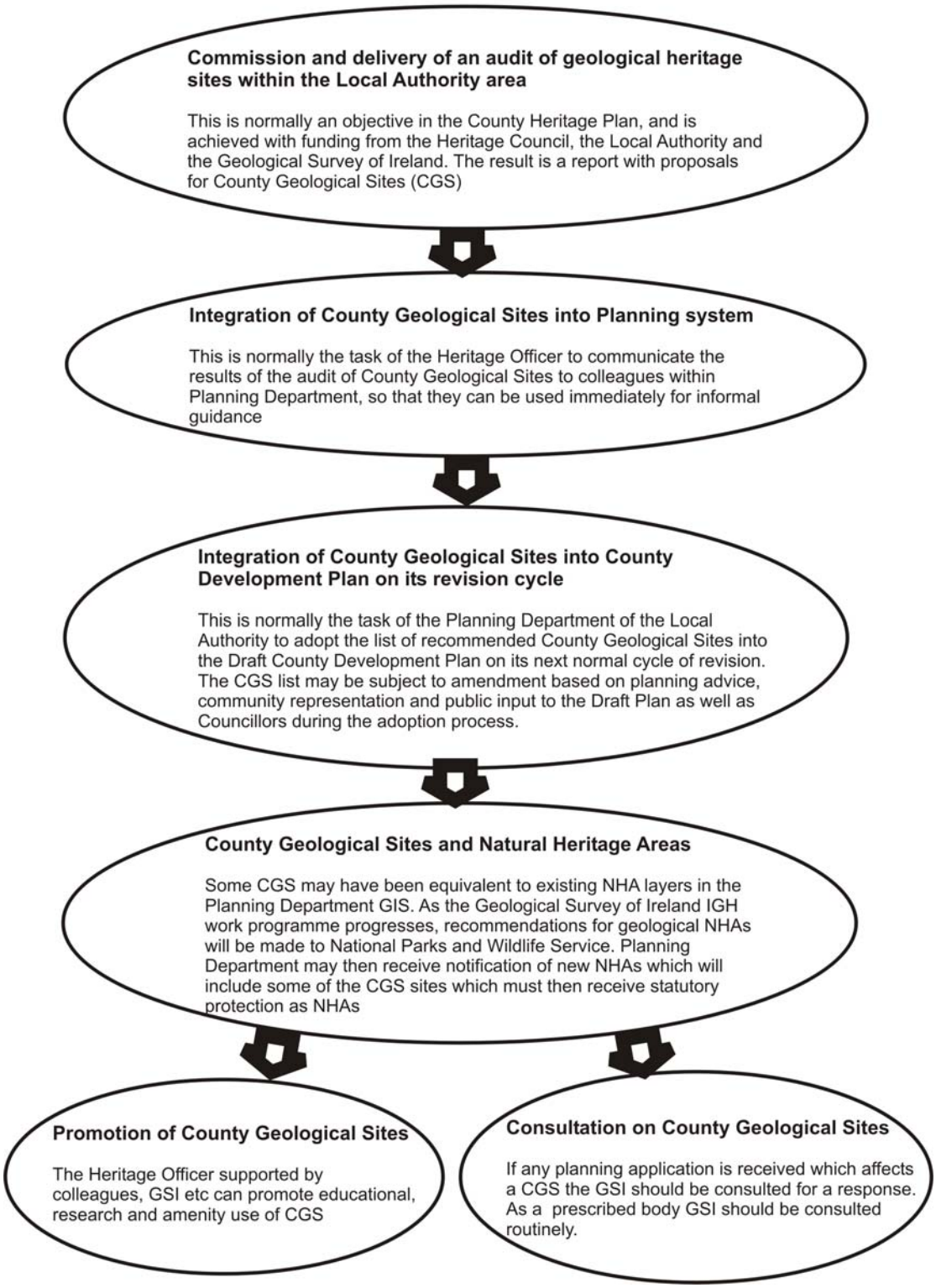
County Kilkenny is a place with a subtle but distinctive landscape. The bedrock foundation, hundreds of millions of years in the formation and shaping, and the more recent history of geomorphological processes involving river channels and glaciers have created an underlying geological diversity or geodiversity for short. Geological understanding and interpretation is best done on the ground at sites where the rocks and landforms are displayed. County Kilkenny has a range of such natural and man-made sites.

This report documents what are currently understood, by the Irish Geological Heritage Programme of the Geological Survey of Ireland, to be the most important geological sites within Kilkenny. It proposes them as County Geological Sites (CGS), for inclusion within the Draft Kilkenny City and County Development Plans (2008-2014). County Geological Sites do not receive statutory protection like Natural Heritage Areas (NHA but receive recognition and an effective protection from their inclusion in the planning system. **The flow chart below summarises the process. Not every Heritage Officer or Local Authority will perceive the process exactly the same, but this chart represents the Irish Geological Heritage Programme view of how it should operate**. But in brief, the sites listed in the report can be used for guidance by the Planning Department, and incorporated as a layer in planning GIS systems. When the next County Development Plan is formulated they can all be formally adopted in the plan as County Geological Sites.

However, a selection of the sites described in this report is considered to be of national importance as best representative examples of particular geological formations or features. They either have been, or will be, formally proposed by the Geological Survey of Ireland, for designation as NHAs by the National Parks and Wildlife Service after due survey and consultation with landowners. However, some of these sites fall within existing NHAs and SACs where the ecological interest is founded upon the underlying geodiversity.

The report also documents a wide variety of geological data sources providing information about Kilkenny. It includes a simple geological history of the county, with maps, charts and a glossary that make the information accessible to those who have not had any formal geological training. This report is written in non-technical language (with a glossary for unavoidable geological terminology) and structured as a working document for use by the Heritage Officer and the Planning Departments of Kilkenny Local Authorities. It is not primarily intended for publication for the general public in its existing form. A chapter of the report includes recommendations on how to best present and promote the geological heritage of Kilkenny to the people of Kilkenny. However the preliminary sections, summary geological history and accompanying map, timescale and stratigraphical column may be used as they stand to preface a booklet or as website information in the development of this work and for information.

County Geological Sites - a step by step guide



Kilkenny in the context of Irish Geological Heritage

To date, Kilkenny is one of only a handful of counties which has commissioned an audit of geological heritage sites within the scope of the County Heritage Plan. It will hopefully act as a model and an inspiration for other councils to follow. It represents a significant commitment on the part of the Local Authority to fulfil its obligations to incorporate geology into the spectrum of responsibilities under the Heritage Act 1995, the Planning and Development Act 2000, Planning and Development Regulations 2001, and the Wildlife (Amendment) Act, 2000 and the National Heritage Plan (2002). The Geological Survey of Ireland views partnerships with the local authorities, such as through this report, as a very important element of its strategy on geological heritage.

Geology in Local Authority planning

Geology is now recognised as an intrinsic component of natural heritage in three separate pieces of legislation or regulations, which empower and require various branches of Government, and statutory agencies, to consult and take due regard for conservation of geological heritage features: Planning and Development Act 2000 [e.g. Sections 212 (1)f; Part IV, 6; Fifth Schedule Condition 21], Planning and Development Regulations 2001, Heritage Act 1995, and the Wildlife (Amendment) Act, 2000. The Heritage Act, and the Planning Regulations in particular, place responsibility upon Local Authorities to ensure that geological heritage is adequately addressed within Heritage Plans, as well as integrated into revised County Development Plans. This can be difficult for Local Authorities if they do not employ any geologists, and few Heritage Officers possess any advanced training in geology.

The Irish Geological Heritage Programme (IGH) in the Geological Survey of Ireland (GSI) complements other nature conservation efforts of the last decade, by assessing Ireland's geodiversity, which is the foundation of the biodiversity addressed under European Directives on habitats and species by the designations of Special Areas of Conservation (SAC) and more recently on a national scale by the introduction of Natural Heritage Areas (NHA) as the national nature conservation method through the Wildlife (Amendment) Act 2000. As a targeted conservation measure to protect the very best of Irish geology and geomorphology it fills a void which has been there since the abandonment of the Areas of Scientific Interest (ASI) scheme, listed by An Foras Forbartha in 1981.

The IGH Programme does this by identifying and selecting the most nationally important geological sites for designation as NHAs. It looks at the whole of Irish geology and geomorphology under 16 different themes. The fundamental approach is that only the minimum number of sites necessary to demonstrate

a particular geological theme is selected. This means that our first criterion is to identify the best national representative example of each feature or major sequence, and secondly any unique or exceptional sites. The third criterion, of selecting any sites of International importance, is nearly always covered by the other two.

IGH THEMES

1. **Karst**
2. **Precambrian to Devonian Palaeontology**
3. **Carboniferous to Pliocene Palaeontology**
4. **Cambrian-Silurian**
5. **Precambrian**
6. **Mineralogy**
7. **Quaternary**
8. **Lower Carboniferous**
9. **Upper Carboniferous and Permian**
10. **Devonian**
11. **Igneous intrusions**
12. **Mesozoic and Cenozoic**
13. **Coastal geomorphology**
14. **Fluvial and lacustrine geomorphology**
15. **Economic geology**
16. **Hydrogeology**

Designation of geological NHAs is undertaken by our partners in the Programme, the National Parks and Wildlife Service (NPWS – formerly a part of Dúchas) in the Department of Environment, Heritage and Local Government. Once designated, any geological NHAs will be subject to normal statutory process within the Kilkenny Planning Department and other relevant divisions. However, management issues for geological sites are generally fewer, and are different from many ecological designations. A later chapter considers these issues.

As a result of extensive comparison of similar sites to establish which is the best, we have a good overview of many other sites, which although not the selected best example, may still be of National importance. Others may be of more local importance or of particular value as an educational site or as a public amenity. These other sites are proposed here for CGS listing in the County Development Plan, along with the clear NHA selections.

At the time of writing this report, candidate sites for Ireland have been established by Expert Panels for all the 16 themes, and the indicative site lists have been finalised. For three themes, the entire process has been essentially completed and detailed site reports and boundary surveys have been included along with a Theme Report. A small number of the sites documented here are already selected and proposed for NHA designation, but due to various factors, they have not been formally designated yet. Members of the Expert Panels for each theme are too numerous to list here but the information is available in GSI's Annual Report for 2003 and on the Heritage Programme's pages on the website (www.gsi.ie).

The procedure for identifying and assessing sites has developed as the whole Irish Geological Heritage Programme has become established. Early thematic reports on Karst, Precambrian to Devonian Palaeontology and Carboniferous to Pliocene Palaeontology (IGH1, IGH2 and IGH3) were done in their entirety, by contractors or by Matthew Parkes. The Expert Panels met to decide which sites should be assessed and prioritised, followed by site reports and fieldwork to allow a basis for selection of the most important for NHA designation.

However, due to lessons learnt in establishing the methodology, and because of urgent demands for information on sites from many quarters, a different approach has evolved. All Expert Panels have concluded their preliminary selection of candidate sites so that we now have a picture of the full range of sites to be examined nationally as candidate NHAs or as County Geological Sites. This is also valuable because sites which have scientific importance under more than one theme can be properly defined in an integrated way. It is hoped that these indicative site lists and location maps will be publicly available on the GSI website in the near future.

Commissioned desk study site reports from members of the Expert Panels for a particular Theme are then followed by field site reporting by IGH Programme staff, including boundary surveys if the sites are suitable. After this stage the Expert Panels review sites to make the final selection for NHA status. Any suitable site may be promoted with a local authority as a County Geological Site, whether or not it goes forward as an NHA at a later stage after full assessment.

The sites proposed here as County Geological Sites (CGS) have been visited and assessed specifically for this project, and represent our current state of knowledge. It does not exclude other sites being identified later as the work of the GSI on the IGH Programme progresses. The project also does not exclude sites which may be directly promoted by the Kilkenny Local Authorities, or by local communities wishing to draw attention to important sites with an intrinsic geological interest for amenity or educational purposes.

Geological conservation issues and site management

The Earth sustains all human society. Soils provide the food we grow and all our material goods are derived from Earth resources extracted from the ground. The Earth also offers hazards and risks with earthquakes, volcanic eruptions, landslides, flooding, tsunami and storms. Understanding the Earth System and our impact upon it is vital to the sustainability of human culture, let alone the viability of all the rest of the enormous biodiversity sharing our planet. Geological heritage is a significant component of understanding the Earth, in that it identifies key places which demonstrate important earth science information. Identification of such places allows strategies to safeguard and promote them for future education and interpretation.

Since **geodiversity is the often forgotten foundation for much of the biodiversity** which has been identified for conservation through SAC or NHA designation, it is unsurprising that many of the most important geological sites are actually the same areas. In these areas, the geological case enhances and cements the value of these sites for nature conservation, but requires no additional designation of actual land areas.

There tend to be two broad types of site identified by the IGH Programme. Most geological sites tend to be small and discrete. They may be old quarries, natural exposures on hilly ground, river sections, or other natural exposures. They usually have a specific interest such as fossils, minerals or are a representative section of a particular stratigraphical sequence of rocks. **The other type of site tends to encompass larger areas that represent a geomorphological interest – landscapes that illustrate processes which formed them**. In Kilkenny, much of the landscape is dominated by the erosional and depositional formations of glacial origin and large areas such as the Ballyfoyle Channels and Inistioge present issues in how to best encompass the geomorphological interest.

It is also important from a geological conservation perspective that Planning Authorities understand the landscape importance of geomorphological features which may not in themselves warrant any formal site designation, but which are an integral part of the character of Kilkenny. A lack of awareness in the past, has led to the loss of important geological sites and local character, throughout the country

There are big contrasts in the management requirements for geological sites in contrast to biological sites. Most geological sites are actually quite robust and generally few restrictions are required in order to protect the scientific interest. In some cases, paradoxically, the geological interest may even be served better by a development exposing more rock. **The important thing is for the sites to be known about in the planning department, and more generally, that geological consultation can take place if some development or change in land use is proposed for a site**. Through this means, geologists may get the opportunity to learn more about a site or area. They may record and sample temporary exposures. Early geological consultation may influence the design of the development so that access to

exposures of rock is maintained for the future. Equally, a strong geological heritage case may occasionally prevent completely inappropriate developments being permitted.

In Kilkenny, as in some other counties, working quarries may be considered as CGS or NHAs simply because they are the best representative sections available of entire sequences, in areas where exposure is otherwise poor. No restriction would be sought on the legitimate operation of these quarries. However, in such cases, for hard rock quarries, maintenance of exposure after quarry closure would be sought with the operator and planning authority. In sand and gravel pits, faces tend to degrade and vegetate once abandoned, but active management of a site can maintain access to the scientific interest once the pit has stopped working, if the site merits it.

One specific area where there are significant difficulties in creating a meaningful geological heritage site is in relation to mine sites. Kilkenny hosts Galmoy Mine, which along with Lisheen Mine in Tipperary and Tara Mine in Navan, Co. Meath make Ireland the largest producer of zinc in Europe. However, the IGH Programme has determined that with most major mines in Ireland it is impractical to select them as either a CGS or an NHA. That includes Galmoy Mine. There are specific issues with the NHA legislation of the Wildlife (Amendment) Act 2000 such that they could only be selected for their mineralisation, and not for any industrial heritage representation. More importantly the practical difficulties outweigh selection as CGS, since modern mining techniques involve total or maximised extraction of the ore with backfilling of waste rock so there is normally nothing to access after mine closure. There are also numerous safety, insurance, permission and legal issues. It is the aspiration of the IGH Programme to negotiate with mine owners and operators for the long term maintenance of small representative sections of geological heritage interest where feasible.

Specific sites may require restrictions and a typical case might be at an important fossil locality or a rare mineral locality, where a permit system may be required for genuine research, but the general opportunity for collecting may need to be stopped. However, Kilkenny's palaeontological sites are not likely to require such an approach, being slow to yield their fauna without very hard work by a palaeontologist.

The previous paragraphs provide some discussion of generic management issues but it is important to note that any proposed development affecting a CGS should lead to early consultation with the IGH Programme on a case-by-case basis. Different developments may generate different issues relating to the geological heritage interest.

In terms of landowner interests, the inclusion of their land within a County Geological Site does not automatically imply severe restrictions on development, but flags the geological importance so that consultation may take place. As noted before, some developments may be positively beneficial in exposing more of the geological character.

New exposures in development

One less obvious area where the Local Authority or the National Roads Authority can play a key role in the promotion and protection of geology is in the case of new roadways. **Wherever new carriageways are built**, or in other major infrastructural work, it should be a policy within the Planning Department that **newly created rock exposures are left open and exposed** unless geotechnical safety issues occur (such as bedding dips prone to rock failure). The grading and grassing over of slopes in cuttings is largely a civil engineering convenience and a mindset which is hard to change. However, it leads to sterile and uninteresting roads which look the same throughout the country. By leaving the rock exposures intersected along the routeway, there is an improvement in character and interest, reflecting the geology and landscape of an area. Sympathetic tree or shrub planting can still be carried out, but leaving bare rocks, especially where they show interesting features, not only assists the geological profession, but creates new local landmarks, to replace those removed in the construction of the roadway. It can also potentially save money on the construction.

Geoparks

An extremely interesting development in geological heritage, not just in Europe, but internationally, has been the rapid recent growth and adoption of the Geopark concept. From an initial European Geoparks Network, there is now a Global Geoparks programme, fully endorsed by UNESCO. A **Geopark is a territory** with a well defined management structure in place (such as Local Authority support), **where the geological heritage is used to develop sustainable tourism opportunities**. A fundamental basis of the Geopark is that it is driven from the bottom up – the communities in the Geopark, are the drivers of the project and are the main beneficiaries. It therefore provides protection of the geological heritage resource so that the community can benefit from it.

In Ireland there are already two members of the European Geopark Network (the Copper Coast in Waterford and Cuilcagh-Marble Arch in Fermanagh), but there are several active proposals in development from Kerry, to the Burren, through the esker landscapes of Offaly and Westmeath to Carlingford in County Louth and the Mourne Mountains. Applications usually need to demonstrate some existing promotion of geological heritage. **It is the opinion of the authors that Kilkenny does not have any areas likely to conform to the quite stringent requirements of an application to the Geoparks Network**.

World Heritage Site status

Previous UNESCO criteria for defining a World Heritage Site allowed only two classifications: either a natural site or a cultural site. This meant that globally, the majority of sites were of cultural heritage. In Ireland, Newgrange and the Boyne Valley archaeological sites (Brú na Bóinne), and the monastic site of Skellig Michael in Kerry were our only World Heritage Sites. In Northern Ireland, the Giants' Causeway is a World Heritage Site of prime geological importance as a natural site.

However, the criteria have been modified recently to reflect a more holistic approach, and to realise that many sites have a natural component and a history of cultural modification which results in unique landscapes. The Burren in County Clare is perhaps the strongest case Ireland has for another World Heritage Site. **It is the opinion of the authors that Kilkenny does not possess any geological sites likely to be suitable as candidate World Heritage Sites**.

Proposals and ideas for promotion of geological heritage in Kilkenny

Specific ideas for projects

Guides
There are very few existing guidebooks to the geology or Quaternary geomorphology of Kilkenny, and none are aimed at a general audience.There is certainly scope for others, and especially for guides at different levels of detail and accessibility to non-specialists. A range of leaflets, booklets, books and other media are all feasible, but the research and production of appropriate text and images is a difficult task to do well without appropriate experience, and adequate time and resources. **However, with appropriate resources, a simple, highly illustrated booklet on the geological heritage of Kilkenny could be compiled for a wide general audience, based on the substance of this report.**

Signboards
Simple explanatory or interpretive signboards may be advisable at some geological heritage locations, but if these are considered, their locations and individual siting should be very selective, since a proliferation of different interest groups may provoke a 'rash' of panels all over the county. A signage strategy could be developed, and its implementation would be subject to consultation with relevant landowners and the Planning Authority, as appropriate. Panels, with their text and graphics require a particular expertise to produce successfully, and the IGH Programme can offer input if signs are desired and planned for key visitor localities. However, given the nature of the majority of sites described in this report, which are on private farmland, or with few suitable parking points to get an overview (e.g. Castlecomer coalfield geology), it is difficult to suggest a suitable site that would benefit from a panel. However, Ballykeefe Quarry would be enhanced by a simple geological explanation on site.

Museum exhibitions
As a result of the work to produce this report, the material for a panel based exhibition has been largely compiled. With some extra resources an interesting exhibition can be put together for display in the Council offices, Libraries etc. A good model is that produced for Carlow, Kildare or for Dun Laoghaire Rathdown [see www.gsi.ie/Programmes/Heritage/Exhibitions].

A most interesting recent development has been the opening of the Castlecomer Discovery Park. This includes a strong component of geology in the mix of history and science it presents for the general public and for school groups. In particular it includes stories of the important fossil heritage of the area and the coal mining heritage, some of which integrates with sites proposed here as County Geological Sites. Real collections on display include material on loan from the Geological Survey of Ireland.

Dunmore Cave, designated as a National Monument for archaeological interest, and in State care (OPW) has a museum/interpretive centre facility for

the general public, explaining the geology of the caves. It also has a new sculpture feature which portrays Ireland's geological story in a spiral of different rock types sourced from different times in the rock record. Rothe House Museum also has some good collections of local fossils such as plants from Kiltorcan, but a great deal more could be done to present them and the stories they tell, in a more interesting and accessible way. No criticism is intended of the museum, simply a recognition that geology is a difficult subject for people to deal with unless they are specialists in the discipline. Professional advice should be sought for any upgrade of these geological elements.

A Kiltorcan plant fossil slab displayed at Rothe House, but with little explanation.

Geoparks

As stated above, it is not considered that any areas are suitable candidates for Geopark status, based on the European and Global Geoparks Network criteria.

World Heritage Site bid

It is not considered that any areas are suitable from a geological or geomorphological perspective as candidate World Heritage Sites. It is understood that the National Parks and Wildlife Service and the Department of Environment, Heritage and Local Government are the recognised body for such a bid from Ireland. There is however, no site in Kilkenny on the tentative list of candidate sites for Ireland on the World Heritage Site Organisation website. If there were any sites under consideration in future, from a wider heritage perspective, then the GSI should be consulted in relation to including a geological assessment in the work, even if it is only a small element, such as sources of building stone etc.

Summary stories of the Geology of County Kilkenny

1) Simple summary:

The varied landscapes that make up Kilkenny have formed over hundreds of millions of years. The underlying bedrock geology of Kilkenny is dominated by Lower Carboniferous rocks, mostly of limestone, which were formed at a time when Ireland was almost completely submerged in tropical waters. To the south of this main body of limestone are older sedimentary and igneous rocks that have formed in a variety of geological environments over the past 500 million years. Some of the last sediments in Kilkenny accumulated during the Quaternary period (1.6 million years ago to present) when a series of large ice sheets moved over Ireland, depositing glacial till (clay, sand and gravel) and scouring the underlying bedrock to give Kilkenny much of its present day geomorphological characteristics.

2) Slightly expanded summary

The geological history of Kilkenny can be told through the rocks and geological formations found in the county. These formations span millions of years in an era known as the Palaeozoic. This can be further split into Upper Palaeozoic (290-410 million years ago) and Lower Palaeozoic (410-544 million years ago). Our story begins at the beginning of the Lower Palaeozoic with the birth of an ocean called the Iapetus Ocean. The opening of the Iapetus split modern day Ireland in two. Deep sea mudstone deposition on the floor of this ocean and volcanism along its margins produced some of the oldest rocks found in Kilkenny. Over the next 140 million years the Iapetus Ocean matured and eventually began to close causing mountain building along its margins. As a result, immense bodies of granite were formed and today the remnants of these rocks can be found around Brandon Hill in the east. The closure of this ancient ocean brings us into the Upper Palaeozoic, a time dominated in Kilkenny by further mountain building and sedimentary deposition, predominantly of limestone. The start of the Upper Palaeozoic is characterised by the formation of mountain ranges and their subsequent erosion and deposition, all occurring in a semi-desert environment. These deposits, consisting of coarse red sandstone and mudstone, occur in the south, stretching from Goresbridge to Ninemilehouse. Kilkenny's geology is dominated by the next phase in its history. About 355 million years ago the Irish landmass began to slowly submerge, beneath shallow tropical seas in which vast amounts of carbonate (limestone) sediments were deposited. The majority of these formations can be found in the north and central parts of the county. Today these rocks are quarried for their aggregate and dimension stone (rock as a building stone) potential. Finally the last stage to affect Kilkenny is a period called the Quaternary. A time dominated by several major ice ages, which occupies the last 1.6 million years of the Earth's geological history. All the surface deposits in Kilkenny (covering most of the county) were deposited during this period and are best shown within numerous economic sand and gravel pits throughout the county.

The varied landscapes in County Kilkenny formed over hundreds of millions of years by various geological processes, each one leaving its mark in the rock record. Careful examination of the rocks in the region can help unravel the story of their formation and thus shed light on the evolution of the Kilkenny terrain.

3) Main summary

Rocks can be divided into three main groups, **sedimentary**, **igneous** and **metamorphic.** Sedimentary rocks are laid down as particles of material such as sand or mud and then hardened by compaction and **lithification** into **sandstones**, **siltstones**, **mudstones** and **limestones**. **Fossils**, often preserved in these rocks, can give us an idea of when the rock formed and what the climate and environment were like at that time. Igneous rocks crystallise from **magma** originating deep beneath the Earth's surface and may be **extrusive** (i.e. **lava** flows at the Earth's surface) or **intrusive** (emplaced within the Earth's **crust**, below the surface). Metamorphic rocks are sedimentary or igneous rocks that have been altered by changes in temperature and/or pressure. New minerals grow in response to these changes and their composition depends on the composition of the original rock, and the temperatures and pressures that affect it.

The predominant rock types in Kilkenny are sedimentary rocks, limestone of Carboniferous age in particular. These sedimentary rocks have only been mildly affected by **folding** and retain many of their original sedimentary and depositional structures. There are also some minor igneous rocks and the larger Arrigle and Blackstairs **Granite Plutons**, which are a part of the Leinster Granite.

At any one locality there is usually more than one rock type, or lithology and they are generally inter-layered. Ranges of lithologies over a small area are largely consistent and sequences of rock often share common characteristics allowing them to be grouped together as packages or geological units. The most important of these 'units' is the **Formation**, which is defined as a sequence of related rock types differing significantly from adjacent sequences.

These formations are mapped as a sequence or succession of units in a **stratigraphical** order, with younger rocks overlying older rocks unless they have been strongly **faulted** or folded. By compiling the formations into a column with oldest at the bottom and youngest at the top we can represent the geological history of an area, with international names for the time periods. The following description of the main events and the rocks they formed in Kilkenny should be read with reference to the map, stratigraphical column and geological timescale. The simplified map of Kilkenny's geology outlines the main units by age. For more detail of the individual formations described it would be necessary to examine the GSI's 1:500,000 scale map

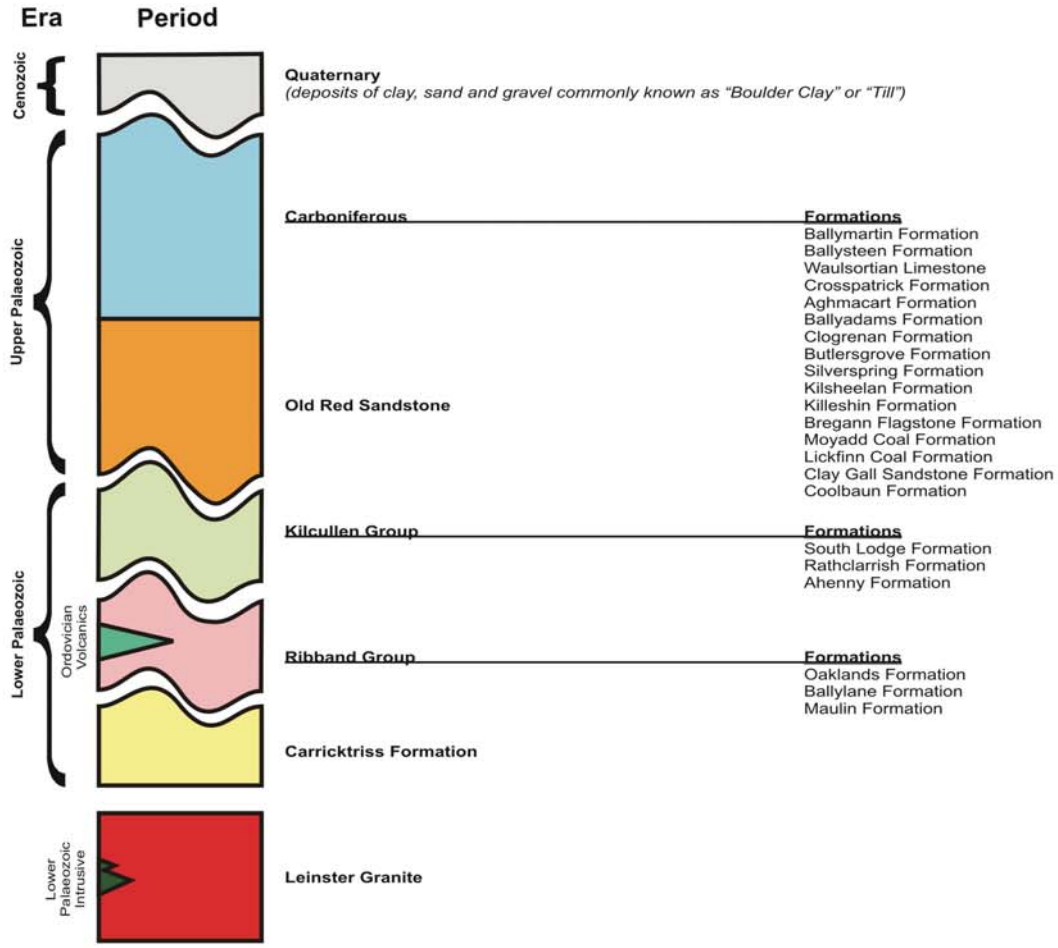
and the 1:100,000 scale maps of the area – Sheet 18 and 19, covering Kilkenny, Tipperary, Carlow and Wexford. They are available from GSI.

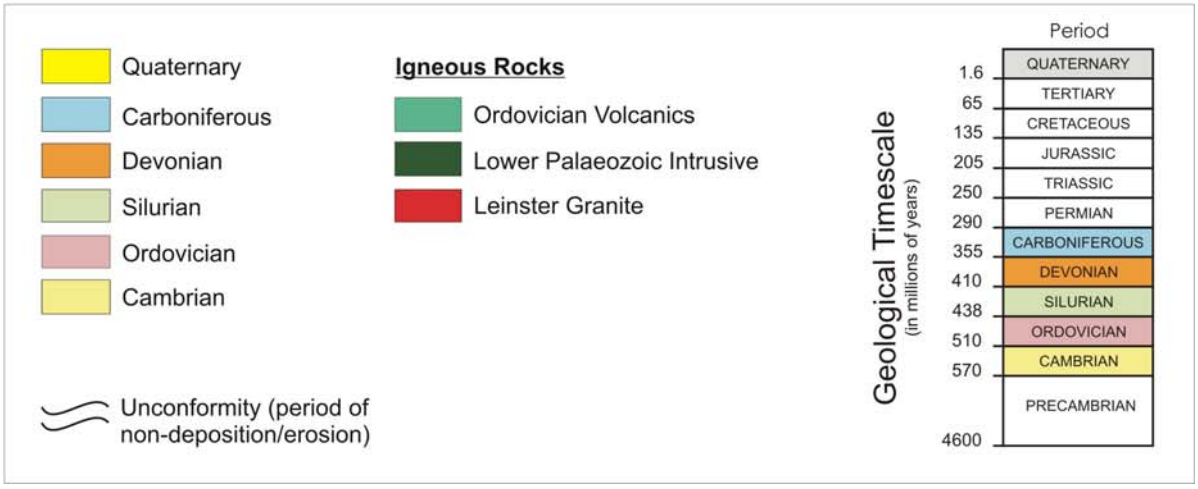
Geological Timescale for Kilkenny

(Age in millions of years)

AGE (Million Years)	ERA	PERIOD		Events Relating to Ireland and Kilkenny (in italics)
1.6	Cenozoic	Quaternary		*A series of ice ages leaving plains of sand and gravel followed by spread of vegetation, growth of bogs and the arrival of man.*
65		Tertiary		Erosion. Opening of the North Atlantic ocean. Volcanoes in NE Ireland.
135	Mesozoic	Cretaceous		Erosion. Probable incursion of the sea. Chalk deposition preserved today in northern Ireland.
205		Jurassic		Uplift and erosion. Sediments deposited offshore.
250		Triassic		Erosion and deposition under desert conditions.
290	Palaeozoic	Upper	Permian	
355			Carboniferous	*Land progressively submerged. Coastal plain and nearshore deposits followed by limestone deposition in shallow tropical seas. Subsequent building out of the land, deltaic sands and muds deposited often under swampy conditions.* Variscan mountain building event (affecting southwest Ireland) towards the end of the Carboniferous.
410			Devonian	*Continued mountain building, rapid erosion and deposition under semi-desert conditions. Intrusion of granites and metamorphism during early Devonian.*
438		Lower	Silurian	*Closure of Iapetus Ocean, continental collision and initiation of Caledonian mountain building.*
510			Ordovician	*Deep-sea mudstone deposition on the floor of the Iapetus Ocean. Volcanism along the southeast margin of Iapetus as the ocean contracts.*
544			Cambrian	Opening of the Iapetus Ocean between northwest and southeast Ireland.
2500	Pre-cambrian	Proterozoic		Oldest rocks in Ireland.
4000		Archaean		Oldest known rocks on Earth.
Formation of the Solar System approximately 4600 million years ago				

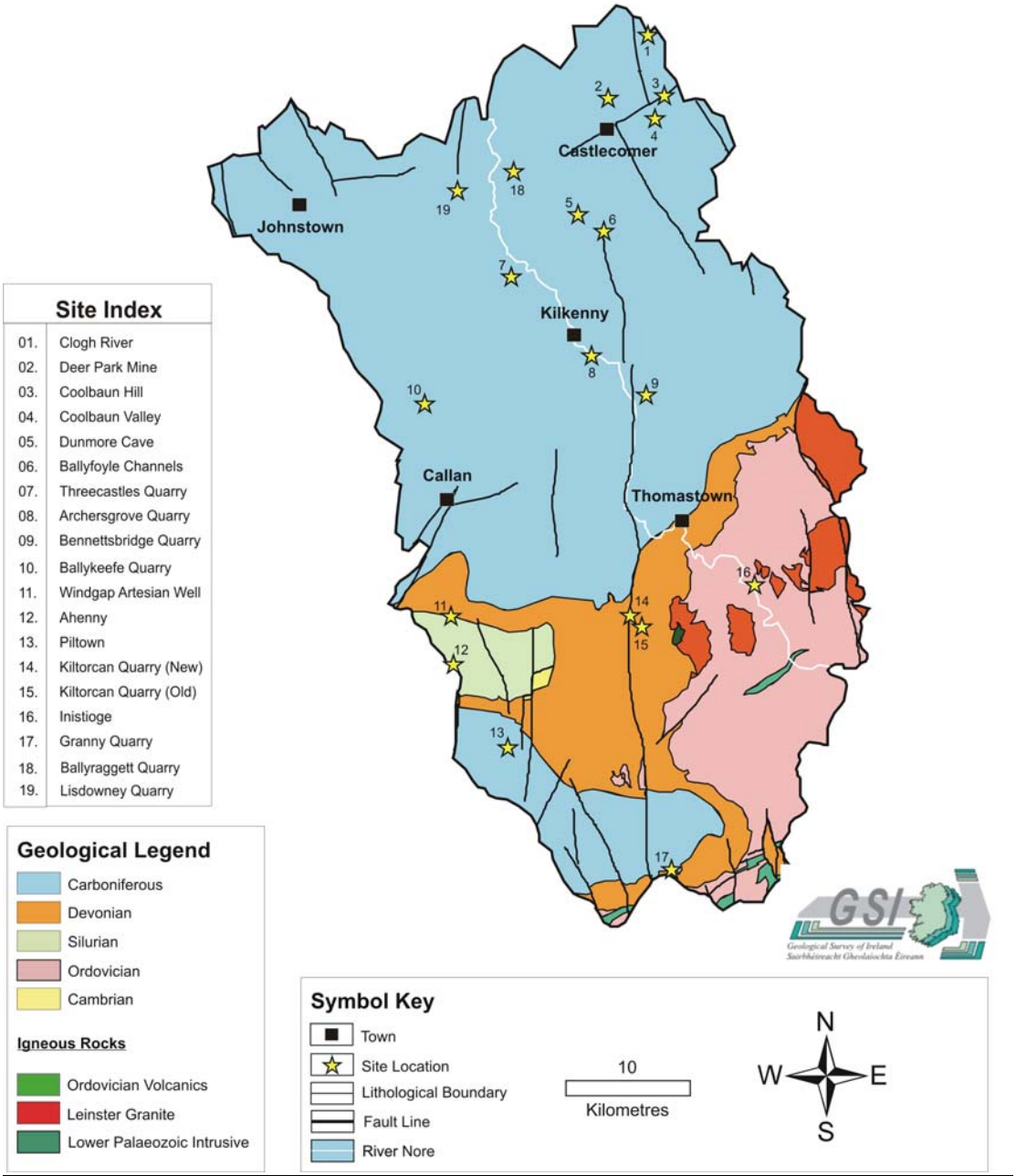
Schematic stratigraphic column summarising the rock sequence in Kilkenny





Summary Geological Map of Kilkenny

(Including Site Locations)



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05.	Dunmore Cave
06.	Ballyfoyle Channels
07.	Threecastles Quarry
08.	Archersgrove Quarry
09.	Bennettsbridge Quarry
10.	Ballykeefe Quarry
11.	Windgap Artesian Well
12.	Ahenny
13.	Piltown
14.	Kiltorcan Quarry (New)
15.	Kiltorcan Quarry (Old)
16.	Inistioge
17.	Granny Quarry
18.	Ballyraggett Quarry
19.	Lisdowney Quarry

Geological Legend

- Carboniferous
- Devonian
- Silurian
- Ordovician
- Cambrian

Igneous Rocks

- Ordovician Volcanics
- Leinster Granite
- Lower Palaeozoic Intrusive

Symbol Key

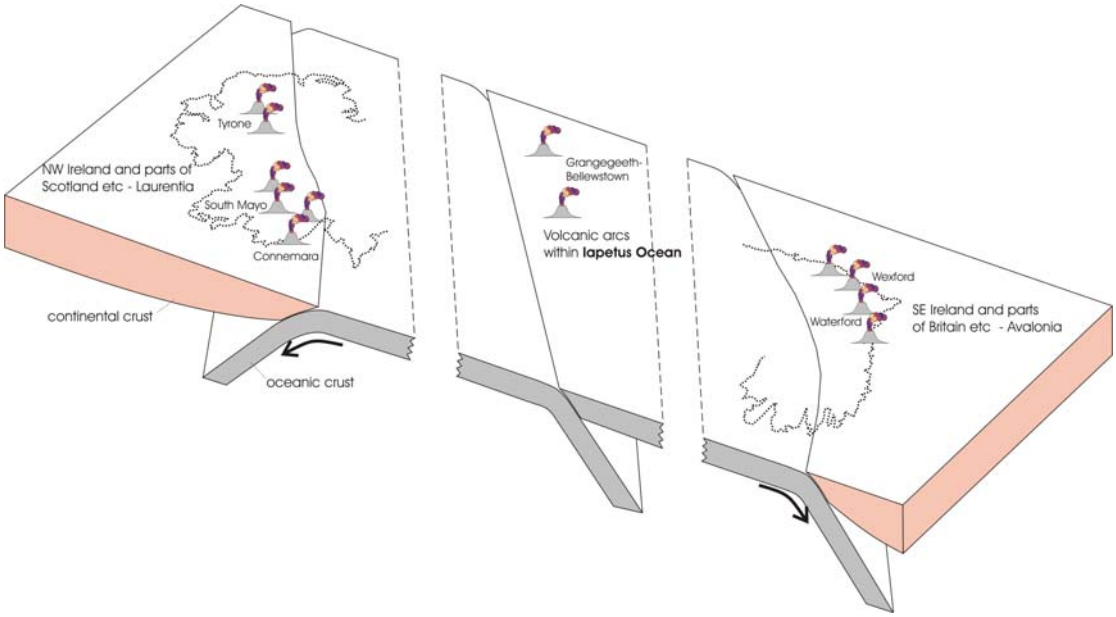
- Town
- Site Location
- Lithological Boundary
- Fault Line
- River Nore

10 Kilometres

N W E S

Lower Palaeozoic

It is now well understood that Ireland is made up of two 'halves', which were originally separated by an ocean that geologists call **Iapetus**. The northwestern half was on the margins of a North American continent, whilst the southeastern half was on the margins of the European continent. **Plate tectonic** movement throughout the Ordovician period saw this Iapetus Ocean close and the two halves converge and eventually combine in Silurian times. Kilkenny's rocks tell part of this story, and need to be understood in the wider context.



Cambrian

The oldest rocks in Kilkenny date back more than 510 million years and are confined to the upland area of Carricktriss Gorse**.** They originated on the "southern" side of the Iapetus Ocean, where they accumulated as layer upon layer of mud. Numerous beds of consolidated **volcanic ash** known as **tuff** indicate the localised presence of an active **volcano**, or possibly several volcanoes. Long after deposition, these Cambrian rocks were strongly deformed and the mudstones metamorphosed to slate to form the Carricktriss Formation. During deformation molten magma was locally injected into these **slates** as **sills**.

Ordovician

The Ordovician rocks in Kilkenny belong to the Ribband Group. This consists of a thick succession of metamorphosed sandstones interbedded with slaty mudstones. They represent continued deposition of abyssal muds on the floor of the Iapetus, by then a fully developed ocean. The slaty mudstones are commonly finely **laminated** so that they have a pinstriped appearance. This lead to the first geologists who mapped them, in the mid 19th Century, to refer to them as being "ribband", a term, which has lent its name to this collection of rocks. Large areas within the Ribband Group have been metamorphosed to form **schists**, which can be seen at Inistioge, where glacial erosion has exposed the underlying **bedrock**. These schists were formed as a result of

heat and pressure produced by the intrusive igneous rocks of the Arrigal and Blackstairs Granites. Minerals within these schists have recorded temperatures in excess of 500°C, generated by the intrusive granites.

Evidence of the first volcanic activity in Kilkenny is found within the Ribband Group occurring towards the top of the Maulin Formation. The Ballyneale Member, made of **andesitic lava** and subordinate **rhyolitic lava** and tuffs, with interbedded sedimentary rocks, is found around the southeast of Ballyneale on the banks of the River Nore. These early Ordovician volcanic rocks may record the onset of volcanic activity associated with the **subduction** of the Iapetus oceanic crust. During this time the Iapetus changed from an ocean that was widening, like the present-day Atlantic, to one in which oceanic crust was being consumed at its margins, like today's Pacific.

Silurian

The next rocks to be deposited are found within the Kilcullen Group, the Silurian succession that makes up part of the Slievenamon Inlier. The apparent absence of Ordovician rocks here suggests uplift and erosion in pre-Silurian times. During the deposition of these mid Silurian rocks enormous quantities of land-derived sediment were deposited into the remnant Iapetus Ocean. They were deposited predominantly by **turbidity currents**, with the Kilcullen Group rocks gradually becoming finer grained upwards, reflecting increasing distance from the sediment source. These sediments, which accumulated on the floor of this ocean, now form enormous thicknesses. The majority of the Silurian rocks within Kilkenny are of the Ahenny Formation (part of the Kilcullen Group). The exposed part of this formation is nearly 3000m thick and consists largely of grey slates, banded with thin siltstone beds. This slate was extensively quarried with good examples seen at Ahenny Quarries (Victoria Slate Quarries) on the Kilkenny-Tipperary border.

Following the deposition of the Lower Palaeozoic sequences, the continents on opposite sides of the Iapetus Ocean were brought together as the ocean floor was consumed by subduction. The extreme pressures of the collision uplifted the rocks to produce a range of mountains, during an event known as the Caledonian **Orogeny**. Rocks were crumpled into folds of differing scales. The axes of these folds and associated **cleavage** are aligned generally northeast southwest and give an idea of the orientation of the mountain range and the continental margins during collision.

The base of the crust was pushed down under the weight of the mountains and the heat at depth caused it to partially melt, producing a large volume of granitic magma. This rose into the upper crust and was intruded as several discrete bodies or plutons. The magma cooled slowly in the crust to form coarse-grained granite. The poorly exposed Arrigal and Blackstairs Plutons can be seen in the southern Kilkenny area. There are a number of plutons making up the Leinster Granite, which runs from Dublin to near New Ross.

The Upper Palaeozoic

Devonian

The closure of the Iapetus Ocean saw the amalgamation of two landmasses forming the Old Red Sandstone Continent (or Laurussia), during the Devonian. Ireland's position within this landmass, which covered most of northwest Europe, had a latitude and therefore climate, similar to that of the Sahara desert today. Marine processes were not a major factor as most of the land lay above sea level. Instead terrestrial processes, such as wind and **fluvial** systems dominated. The Old Red Sandstone Continent remained throughout the Devonian from about 410 to 360 million years ago.

During the late Devonian and the early Carboniferous mountain torrents transported rocky debris from uplands to lowlands. As the loose stones were buffeted about by the torrential rivers their surfaces were smoothed and rounded. Eventually, many accumulated as gravel bars within **braided river** courses and have been preserved as close-packed **conglomerates**. As time went on, and the mountains were worn away by erosion, other types of **alluvial deposits** accumulated. The gravels and sands left behind by meandering rivers form the conglomerates and the sandstones which make up most of the Old Red Sandstone. The finer grained red sandstones, red siltstones and red mudstones which are associated with the coarser conglomerates and sandstones accumulated on the **floodplains** of the meandering rivers, the red colouration reflecting the arid, **sub-aerial** oxidising conditions under which these rocks formed.

The wearing-away of the Caledonian Mountains is reflected throughout the Old Red Sandstone by the gradual disappearance of conglomerates and coarse sandstones higher in the sequence. Evidence of climatic change can be detected in the upper levels of the Old Red Sandstone succession. Wetter conditions resulted in the replacement of the redbeds by greenish-grey siltstones, which very occasionally contain fossil plants. Evidence from plant spores shows that at least the topmost beds of the Old Red Sandstone within the Kiltorcan Formation were deposited in earliest Carboniferous times. Climatic change was followed by radical environmental change, as the Lower Carboniferous sea encroached upon the Old Red Sandstone continent. The gradual change from coastal plain conditions to a marine environment is recorded in the rocks which form the top of the Old Red Sandstone succession (e.g. Kiltorcan Formation) and the overlying marine Lower Limestone Shales.

Carboniferous

The uplift and partial erosion of the Lower Palaeozoic rocks and plutonic rocks during the Devonian and earliest Carboniferous left broad lowlands, across which fluvial red-bed sediments (youngest Old Red Sandstone) accumulated. General subsidence permitted the sea to invade the lower ground from the south during the Carboniferous. The initial marine sediments were intertidal **laminated** muds and sands. Offshore sands accumulated in deeper water.

Continued **subsidence** resulted in shallow and then deeper water sediments (Ballysteen Formation) accumulating across most of the Kilkenny area. The depth of the sea and type of seafloor varied from place to place, producing a variety of **carbonate** sediments at any one time. The warm and clean shallow seas of this period produced an environment teeming with marine organisms, including **brachiopods**, **gastropods**, **crinoids** and a great variety of **corals** all preserved in Kilkenny's limestone (e.g. Kilkenny Black Marble).

Occurring midway through the Carboniferous limestone deposition was the development of sea-bed mudbanks, which built up to form the thick Waulsortian Limestone Formation. This massive, fine grained limestone is characterised by frequent irregular cavities filled with crystalline **calcite**. Deposited after the Waulsortian Limestone Formation is another limestone called the Ballyadams Formation, which is exposed in several quarries throughout Kilkenny. It is characterised by the presence of several thin and irregular clay beds called clay wayboards. These represent periodic shallowing of the sea and temporary exposure of the seabed above sea level leading to the formation of clay soils.

Stretching of the Earth's crust beneath Ireland during this period of limestone deposition permitted percolation of mineralised fluids up faults in the rocks. These fluids selectively altered the limestone into magnesium-enriched **dolomite** in a process known as **dolomitization**. One of the largest of these faults runs along the River Nore through Bennettsbridge Quarry where dolomite is quarried today. Other minerals such as lead, zinc and iron percolated up through these faults forming economic deposits within the limestone. These valuable ore deposits are currently being extracted in places like Galmoy (Arcon Mines) in Kilkenny and Lisheen Mines in Tipperary.

The deposition of predominantly calcareous sediments came suddenly to an end at the close of the Lower Carboniferous. A period of very slow deposition in quiet, possibly deep waters followed. Then, the uplift and erosion of mountain areas to the north of Ireland gave rise to vast quantities of land-derived sediments being carried by rivers across the Kilkenny area to form **deltaic** and related deposits of sand and mud. As the deltas spread southwards, low-lying swamps and sea level forests extended into the sea, and in due course became buried themselves, to form **coal** deposits now preserved in the Castlecomer Coalfield district. Sites such as Deer Park, Coolbaun Valley and Coolbaun Hill represent this period.

(Permian, Triassic, Jurassic, Cretaceous and Tertiary)
The subsequent periods have largely left no trace as rocks on the land. It is inferred that Ireland was mostly land, subject to weathering and erosion, which supplied the offshore basins with sediment. During the Tertiary period Ireland probably suffered karstic weathering like the famous tower karst of Guilin in China. The Piltown site is evidence of the processes and environments.

Quaternary

The Quaternary Period is the latest one of the geological timescale. It marks the period of the Ice Age, which began about 1.6 million years ago, and the postglacial period or Holocene, which extends to the present day. All of the surface deposits in the Kilkenny area were deposited during the Quaternary Period. Most of the sediments were deposited during the Ice Age itself, either directly from the huge ice sheets that spread across the area or by meltwater flowing from the ice sheets as they finally melted. The Irish ice sheet, like its modern counterparts in Greenland and Antarctica, was formed by a number of coalescing ice domes from which ice flowed radially outwards. As it did so it ground down the underlying bedrock, breaking down protruding pieces and further breaking these down. The end result of this process is sediment within and beneath the ice sheet. This may include particles of all sizes ranging from clay to boulder and which, when spread over the land surface by glacial ice, is known as **till** (commonly known as boulder clay). Alternatively, sediments may be carried and sorted by meltwater and deposited as sand and gravel, with silt and clay deposited separately in lake systems or carried away to the sea. These glacial deposits therefore contain fragments of the type of bedrock over which the ice passed. In addition they contain sedimentary information, which tell us about the conditions in which they were deposited, whether underneath or on the margins of the ice sheet. Glacial and **glaciofluvial** deposits in Kilkenny can be as much as 10m thick in this area and are at their thickest along parts of the Nore Valley. Many of the glacial features seen in Kilkenny are erosional. At Inistioge and Ballyfoyle the underlying bedrock has been carved out by streams beneath the ice, leaving gorges behind.

Glossary

Alluvial Deposit	unconsolidated clay, silt, sand and gravel, deposited by a body of running water.
Andesite	a volcanic rock of intermediate composition (between rhyolite and basalt).
Bedrock	a general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material.
Boulder Clay	unconsolidated, unsorted glacial deposits consisting of boulders and cobbles mixed with very finely ground-up rock or silt.
Brachiopods	a marine invertebrate of the phylum Brachiopoda characterised by a lophophore and by two bilaterally symmetrical values. Ranging from Lower Cambrian to present.
Braided River	a river that consists of a network of small channels separated by small and often temporary islands called braid bars.
Calcite	a pale mineral composed of calcium carbonate, which reacts with dilute hydrochloric acid.
Carbonate	a rock (or mineral), most commonly limestone (calcite) and dolomite.
Cleavage	a flat plane of breakage caused by compressive deformation of rocks. e.g. the splitting of slate.
Coal	a fossil fuel comprised primarily of carbon formed by the decomposition of plant matter in non-marine environments millions of years ago.
Conglomerate	a sedimentary rock comprising large rounded fragments in a finer matrix.
Crinoid	a variety of sea-urchin, with a long flexible stem, usually anchored to the sea-floor and a body cup with arms which may be branching (a sea lily).
Crust	the outermost, solid, layer of the Earth.
Delta	a low, nearly flat alluvial tract of land at or near the mouth of a river, commonly forming a fan or triangular shaped plain of considerable area, which is crossed by many smaller channels of the main river.
Dolomite	calcium and magnesium-bearing carbonate mineral; also a rock, usually forming when magnesium replaces some of the calcium in limestone after burial.
Dolomitization	a chemical process in which magnesium rich fluids replaces calcium within limestone to produce dolomite.
Extrusive	an igneous body emplaced (erupted) at the Earth's surface as lava.
Fault	planar fracture in rocks across which there has been some displacement.
Floodplain	a flat or nearly flat land area adjacent to a stream or river that experiences occasional or periodic flooding.
Fluvial	of or pertaining to rivers.
Fold(ing)	flexure in layered rocks caused by compression.

Formation	a sequence of related rock types differing significantly from adjacent sequences.
Fossils	any remains, trace or imprint of a plant or animal that has been preserved in the Earth's crust since some past geological or prehistoric time.
Gastropod	a marine, freshwater or terrestrial invertebrate with a shell which has a conical or helical spiral shape (a snail).
Glacial	of or relating to the presence and activities of ice or glaciers.
Glaciofluvial	pertaining to the meltwater streams flowing from wasting glacier ice and especially to the deposits and landforms produced by such streams.
Granite	a coarsely crystalline intrusive igneous rock composed mostly of quartz and feldspar.
Igneous	a rock or mineral that solidified from molten or partially molten material i.e. from a magma.
Intrusive	an igneous rock emplaced within the Earth's crust, not extruded like lava.
Laminated	extremely fine stratification or bedding, typically exhibited by shales and fine-grained sandstones.
Lava	magma extruded onto the Earth's surface, or the rock solidified from it.
Limestone	a sedimentary rock consisting chiefly of calcium carbonate ($CaCO_3$), primarily in the form of the mineral calcite. It is mostly formed by the accumulation of calcareous shells, cemented by calcium carbonate precipitated from solution.
Lithification	the process of rock formation from unconsolidated sediment.
Lithology	the description of rocks on the basis of such characteristics as colour, composition and grain size.
Magma	molten rock, which cools to form igneous rocks.
Metamorphic	referring to the process of metamorphism or to the resulting metamorphic rock, transformed by heat and pressure from an originally igneous or sedimentary rock.
Mudstone	a very fine grained sedimentary rock, containing quartz and clay minerals. Similar to shale, but not as easily split along the plane of bedding.
Orogeny	the creation of a mountain belt by tectonic activity.
Outcrop	part of a geologic formation or structure that appears at the surface of the Earth.
Plate Tectonics	a dynamic process driving the interaction between a series of interlocking crustal plates along their plate boundaries, e.g. by subduction.
Pluton	an igneous intrusion formed at sufficient depths to allow for the slow growth (crystallisation) of large crystals.
Rhyolite	an igneous, volcanic (extrusive) rock of acidic composition. The mineral assemblage is usually quartz and alkali and plagioclase feldspars.

Sandstone	a fine to coarse sedimentary rock, deposited by water or wind, and composed of fragments of sand (quartz grains), cemented together by quartz or other minerals.
Schist	a medium to coarse grained rock, formed by the metamorphism of a sedimentary mudstone by heat and pressure. The minerals are aligned in parallel layers giving the rock a fabric known as schistosity.
Sedimentary	a rock formed by the deposition of sediment, or pertaining to the process of sedimentation.
Siltstone	is similar to mudstone but with a predominance of silt-sized (slightly coarser) particles.
Sill	a tabular mass of igneous rock that has been intruded horizontally between layers of existing rock.
Slate	is a fine-grained metamorphic rock produced from a sedimentary mudstone by pressure, imposing a cleavage along which the slate easily splits.
Stratigraphy	the study of stratified (layered) sedimentary and volcanic rocks, especially their sequence in time and correlation between localities.
Sub-aerial	refers to processes occurring above ground level, such as the weathering of rocks.
Subduction	the sinking of one crustal plate beneath the edge of another through the process of plate tectonics.
Subsidence	the sudden sinking or gradual downward settling of the Earth's surface with little or no horizontal movement.
Till	unconsolidated, unsorted glacial deposits consisting of boulders and cobbles mixed with very finely ground-up rock such as sand, silt or clay.
Turbidity Current	underwater density current carrying suspended sediment at high speed down a subaqueous slope. The resulting deposit is called a turbidite.
Tuff(aceous)	consolidated rock formed from the ash ejected from a volcano.
Volcanic Ash	very fine rock and mineral particles ejected from an erupting volcano.
Volcano	a vent in the surface of the Earth through which magma and associated gasses and ash erupt.

Data sources on the geology of County Kilkenny

This section is a brief summary of relevant GSI datasets, to assist any enquiry concerning geology to target possible information easily. The GSI has very many datasets, accumulated since it began mapping Ireland's geology in 1845. A recent project has established a Document Management System into which about half a million documents and maps have been scanned. This means that any user can visit the GSI Customer Centre themselves and search on screen for data of relevance to them. High quality colour and black and white prints can be made or data supplied on CD. Data is now provided free but a small service charge may apply.
Key datasets include:

1:100,000 Map Report Series

All historical, modern and other mapping has been compiled into very useful maps and reports that describe the geology of the entire country. Sheets 18 and 19 cover Kilkenny. In addition digital mapping from the 1:100,000 series is now available on a seamless national basis and customised output can be produced for specific areas.

19th century 6 inch to the mile fieldsheets

These provide an important historical and current resource, with very detailed observations of the geology of the entire country. These are also now available seamlessly on line through the GSI website www.gsi.ie. The Archives of the GSI also include a set of first edition Ordnance Survey six inch to the mile maps, which generally predate the geologically coloured fieldsheets. For historical study they can be useful in showing changes through time.

19th century one inch maps and Memoirs

Information from the detailed 19th century mapping was distilled into one inch to the mile maps, of which Sheets 136, 137, 146, 147, 156, 157, 167 and 168 include parts of Kilkenny. Each sheet or several sheets were accompanied by a Memoir which described the geology in some detail. These still provide valuable records of observations even though interpretations may have changed with better geological understanding.

MinLocs Data

The MinLocs Database records all known mineral occurrences, however small, from GSI records, such as 19th century fieldsheets and Open File data. These include economic deposits such as sand and gravel pits, brick clays, and building stones as well as metallic and non-metallic minerals.

Historic Mine Records

Abandonment plans and varied other material exists for the various mining and exploratory ventures in the county, at places like Castlecomer.

Quaternary Mapping

Since a Groundwater Protection Scheme has been completed for County Kilkenny by GSI, a modern mapping of the Quaternary sediments exists as

well as bedrock mapping. This provides a significant resource in general terms as well as for groundwater protection. Customised output is possible.

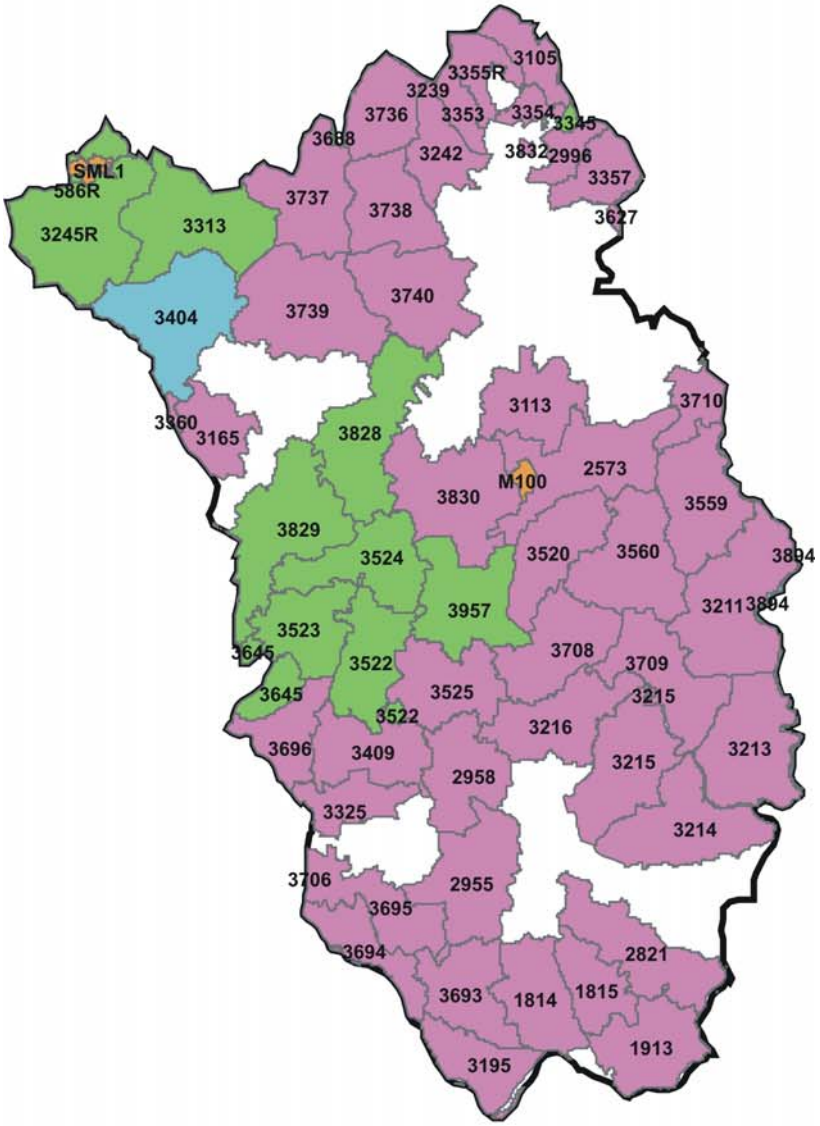
Aerial Photography
The GSI has almost full coverage of the country in 1973 black and white Air Corps vertical aerial photography, which together with a stereoscope can be very useful in interpreting geological and geomorphological features. Partial coverage of 1954 photography is also available. All are available for public consultation, with a stereoscope in the Customer Centre of GSI.

In addition the GSI network has more recent digital ortho photography and colour aerial photography from about 2000 or 2004 which can be consulted for particular purposes on request, but OSi copyright applies.

Open File Data
Each Mineral Prospecting Licence issued by the Exploration and Mining Division of the Department of Communications, Energy and Natural Resources (currently) carries an obligation on the exploration company to lodge records of the work undertaken, for the common good. These records are held by the Geological Survey and are available as Open File Data, once a period of time has expired. They may include geological interpretations, borehole logs, geophysical and geochemical surveys and so on. Exploration is based on defined areas known as Prospecting Licences (PL) which allow someone the right to search and investigate for minerals under the ground within the PL or a block of PLs. The PLs covering Kilkenny and their current status are shown below.

Prospecting Licence Designation Supplied By Exploration and Mining Division (EMD)

Department of Communications, Marine and Natural Resources
Roinn Cumarsaide, Mara agus Acmhainni Nadurtha



Prospecting Licence Designation

- Held
- Mining Lease
- Open
- Open - Exploration Incentives
- 3195 Licence Number

N
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Shortlist of Key Geological References

This reference list includes selected papers, books and articles that are recommended as access points to Kilkenny's geological heritage. A full reference list of papers relating to the geology of County Kilkenny is contained in Appendix 2, including any references cited in the individual site reports.

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Introduction to geology in general

DUNNING, F.W., ADAMS, P.J., THACKRAY, J.C., van ROSE, S., MERCER, I.F. and ROBERTS, R.H. 1981. *The story of the Earth*. (2nd edition). Geological Museum, H.M.S.O., 36pp.

EDMONDS, E. 1983. *The geological map: an anatomy of the landscape*. Geological Museum, H.M.S.O., 36pp.

HOLMES, A. 1978. *Principles of Physical Geology*. (3rd edition revised by D. Holmes), Thomas Nelson, 730pp.

THACKRAY, J. 1980. *The age of the Earth.* Geological Museum, H.M.S.O., 36pp.

Introduction to the geology of Ireland

AALEN, F.H.A., WHELAN, K. and STOUT, M. (eds) 1997. *Atlas of the Irish rural landscape.* Cork University Press, Cork.

FEEHAN, J. and O'DONOVAN, G. 1996. *The Bogs of Ireland. An Introduction to the Natural, Cultural and Industrial Heritage of Irish Peatlands*. *University College Dublin. The Environmental Institute.*

HOLLAND, C.H. (ed.). 2001. *The Geology of Ireland*. Dunedin Academic Press, Edinburgh.

HOLLAND, C.H. 2003. The Irish Landscape. A scenery to celebrate. Dunedin Academic Press, Edinburgh. 180 pp.

KENNAN, P. *Written in Stone*. Geological Survey of Ireland, 50pp. [*Also DVD/VCR of TV Series*]

MITCHELL, F. and RYAN, M. 1997. *Reading the Irish Landscape*. Town House. Dublin. 392 pages.

SLEEMAN, A.G., McCONNELL, B. and GATLEY, S. 2004. *Understanding Earth Processes, Rocks and the Geological History of Ireland*. Geological Survey of Ireland, Dublin. 120 pp, including map and CD.

STILLMAN, C. and SEVASTOPULO, G. 2005. Leinster. Classic Geology in Europe 6, Terra Publishing, Harpenden, Herts. 192 pp.

WHITTOW, J.B. 1974. *Geology and Scenery in Ireland.* Pelican Books, 301pp.

WILLIAMS, D.M. and HARPER, D. 1999. *The Making of Ireland*. Landscapes in Geology. Immel Publishing, London. 98 pp.

Introduction to geology of Kilkenny (and adjoining areas) in particular

CONRY, M.J. 2006. Carlow Granite: years of history written in stone. Chapeltown Press Ltd., Carlow. 368 pp.

HEGARTY, S. 2002. The Quaternary of Kilkenny (with particular emphasis on the Castlecomer Plateau). Irish Quaternary Association Field Guide 24. Irish Quaternary Association, Dublin. 52 pp.

TIETZSCH-TYLER, D. 1995. *Building Stones of St. Canice's Cathedral, Kilkenny. An Introduction to the Rocks of the Kilkenny Region.* Geological Survey of Ireland and Board Fáilte, Ireland.

WALSH, J. and WALSH, S. 1999. *In The Shadow of the Mines.* J & G Print, Freshford.

Further sources of information and contacts

The Geological Survey of Ireland, and the Head of the Irish Geological Heritage Programme, Sarah Gatley can be contacted in relation to any aspect of this report. Dearbhala Ledwidge, the Heritage Officer of Kilkenny Local Authorities, is the primary local contact for further information in relation to this report. Other contacts are the Conservation Rangers of the National Parks and Wildlife Service, of the Department of Environment, Heritage and Local Government. The names and phone numbers of current staff may be found in the phone book.

Web sites of interest

www.gsi.ie - for general geological resources
http://www.habitas.org.uk/es2k/index.html - for general geological information of wide interest
http://www.tcd.ie/Geography/IQUA/Index.htm - for information, fieldtrips, lectures etc in relation to Ireland's Ice Age history
http://www.sgu.se/hotell/progeo/index.html - for information about ProGEO the European Association for the Conservation of Geological Heritage

County Geological Site Reports – General Points

The following site reports are brief non-technical summaries of the proposed County Geological Sites for Kilkenny. These have been specially prepared for this Report in order to make the information accessible to planners and others without geological training. For most sites more detailed reports and information files are held in the IGH Section in the Geological Survey of Ireland. These are available for consultation if required. Further sites may become relevant as IGH Programme work develops.

Each site report has primary location information, a mention of the main rock types and their age, and a short description of the key aspects of scientific interest. A section outlining any particular management or other issues specific to the site is included, along with one or two low resolution photographs exemplifying the site. CD's accompanying this report will include further pictures of most sites at higher resolution. Grid references are given normally for a central point in the site, or two extreme points at opposite ends of the site.

GIS shapefiles with associated attribute tables will be provided with an outline of the site boundaries. It is important to note that no legal or definitive basis should be based on these boundaries. They are indicative only of the limits of exposure or of geological interest, and not based on detailed field surveys, which were outside the scope of this contract.

For sites that have been proposed or will be proposed for NHA designation detailed site boundary maps will become available to the Local Authority, through NPWS as the designation process is undertaken. **In terms of any geological heritage site designation as NHA, due process of site reporting, boundary survey and very importantly, consultation with landowners where they can be readily identified, will take place before GSI makes recommendations to NPWS on the sites to be designated.**

Any landowner within areas or sites identified in this report with concerns over any aspect of this project is encouraged to contact Sarah Gatley at the Irish Geological Heritage Programme, in the Geological Survey of Ireland, Beggars Bush, Haddington Road, Dublin 4.
Phone 01-6782837. Email: sarah.gatley@gsi.ie

Map/Photo Scales

In the following section each site has a segment of 1:50,000 Ordnance Survey of Ireland map, and/or a segment of 1:10,560 (six inch to the mile) OSi map and/or a colour aerial photograph (year 2000). The displayed scale is variable, i.e. they have been zoomed in or out to best show the limits of the site in the page space available. They are therefore indicative only and should not be used with assumption that they are all at the same or standard scale. Dates of publication on maps vary considerably.