The Geological Heritage of Louth

An audit of County Geological Sites in Louth

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November 2013

The Louth Geological Heritage Project was supported by

An Chomhairle Oidhreachta
The Heritage Council

GSI
Suirbhéireacht Gheolaíochta Éireann
Geological Survey of Ireland

Údaráis Áitiúla Lú
Louth Local Authorities

Louth Heritage Forum
Fóram Oidhreachta Lú

**This report is an action of the
County Louth Heritage Plan 2007 – 2011**

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Report Summary

County Louth is one of Ireland's smaller counties but its geology is quite diverse and there is a relatively high proportion of sites of geological heritage interest. These are found mainly in the Carlingford district and in coastal areas, since natural exposures of geology are best found in uplands and on coasts.

This report documents what are currently understood by the Irish Geological Heritage Programme (IGH) of the Geological Survey of Ireland (GSI) to be the most important geological sites within Louth. It proposes them as County Geological Sites (CGS), for inclusion within the Louth County Development Plan (CDP). The audit provides a reliable study of sites to replace a provisional listing based on desk study which was adopted in a previous CDP.

County Geological Sites do not receive statutory protection like Natural Heritage Areas (NHA) but receive an effective protection from their inclusion in the planning system. However, many of the sites described in this report are considered to be of national importance as best representative examples of particular geological formations or features. They 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, many of these sites fall within existing pNHAs and SACs where the ecological interest is founded upon the underlying geodiversity. The commission of this audit and adoption of the sites within the County Development Plan ensure that County Louth follows a now established and effective methodology for ensuring that geological heritage is not overlooked in the general absence of allocated resources for progress at national level. It ensures that Louth remains at the forefront of geological conservation in Ireland, and should contribute to the development of the planned application for a cross-border Mournes, Cooley and Gullion Global Geopark.

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This report is written in non-technical language (with a glossary for unavoidable geological terminology) as a working document for use by the Heritage Officer and the Planning department of Louth County Council. It will also be made available via the County Council website for the people of Louth. A chapter of the report includes recommendations on how to best present and promote the geological heritage of Louth to the people of the county. It will also inform the work of the IGH Programme and be made available through the GSI website.

The preliminary sections, summary geological history and accompanying map, timescale and stratigraphical column particularly may be used as they stand to preface a booklet or as website information in the development of this work, and for information as seen fit by the Heritage Officer. The contents also provide the essential ingredients for a public-oriented book on the geological heritage of Louth, if the funding can be found to produce it.

Louth in the context of Irish Geological Heritage

This report ensures Louth remains active at the forefront of geological heritage within Ireland, as it is one of half of Ireland's counties to commission such an audit within the scope of the county-based Heritage Plan. It will hopefully encourage other local authorities to follow what is now a tried and trusted methodology. In the absence of significant political and economic resources available at a national level to the relevant bodies for conservation of geological heritage as Natural Heritage Areas (NHA), it represents a significant level of progress in defining and safeguarding Ireland's geological heritage.

It also 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). GSI views partnerships with the local authorities, exemplified by this report, as a very important element of its strategy on geological heritage (see Appendix 1).

The Irish Geological Heritage Programme (IGH) in 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. As a targeted conservation measure to protect the very best of Irish geology and geomorphology it fills a void which has existed since the abandonment of the Areas of Scientific Interest scheme, listed by An Foras Forbartha in 1981.

The IGH Programme does this by identifying and selecting the most important geological sites nationally for designation as NHAs. It looks at the entire spectrum within Irish geology and geomorphology under 16 different themes:

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

A fundamental approach is that only the minimum number of sites necessary to demonstrate the particular geological theme is selected. This means that the first criterion is to identify the best national representative example of each feature or major sequence, and the second is to identify any unique or exceptional sites. The third criterion, identifying any sites of International importance, is nearly always covered by the other two.

Designation of geological NHAs will be by the GSI's partners in the Programme, the National Parks and Wildlife Service (NPWS). Once designated any geological NHAs will be subject to normal statutory process within the Louth Planning Department and other relevant divisions. **However, compared to many ecological sites, management issues for geological sites are generally fewer and somewhat different in nature. The subsequent section considers these issues**.

From a national perspective, as a result of extensive comparison of similar sites to establish the best among them, there is now a good knowledge of many other sites, which are not the chosen best example, but may still be of national importance. Others may be of more local importance or of particular value as educational sites or as a public amenity. It is these various other important sites that are proposed for County Geological Site (CGS) listing in the County Development Plan, along with any clear NHA selections.

Currently, in 2013, a Master List of candidate CGS and NHA sites has been established in GSI with the help of Expert Panels for all the 16 IGH themes. For several themes, the entire process has been largely completed and detailed site reports and boundary surveys have been done along with a Theme Report. Due to various factors, none have been formally designated yet as Natural Heritage Areas (NHA). Therefore, inclusion of all sites as County Geological Sites (CGS) in Louth's planning system will ensure that they are not inadvertently damaged or destroyed through lack of awareness of them outside of the IGH Programme in GSI.

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, or directly promoted by the Council itself, or by local communities wishing to draw attention to important sites for amenity or education with an intrinsic geological interest. New excavations, such as major road cuttings or new quarries for example, can themselves be significant and potential additions to this selection.

It was not possible within the scope of this study to identify landowners except in a few sites, but it is emphasised that listing here is not a statutory designation, and carries no specific implications or responsibilities for landowners. It is a primarily a planning tool, designed to record the scientific importance of specific features, and to provide awareness of them in any decision on any proposed development that might affect them. It thus also has an educational role for the wider public in raising awareness of this undervalued component of our shared natural heritage.

Geological conservation issues and site management

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 in the same areas as SAC and NHA sites. In these areas, the geological heritage enhances and cements the value of these sites for nature conservation, but requires no additional designation of actual land areas.

Broadly speaking, there are two types of site identified by the IGH Programme. The first, and most common, includes small and discrete sites. These may be old quarries, natural exposures on hilly ground, coastal cliff sections, or other natural cuttings into the subsurface, such as the Collon Quarry or Oriel Brook sites. They typically have a feature or features of specific interest such as fossils or minerals or they are a representative section of a particular stratigraphical sequence of rocks. **The second type of site is a larger area of geomorphological interest, *i.e*. a landscape that incorporates features that illustrate the processes that formed it**. The Quaternary theme includes such sites. In Louth, the superb subglacial bedforms (drumlins) are characteristic of the larger sites encompassed under the IGH 7 Quaternary Theme. Extensive areas of Louth's landscape are covered by drumlins, which can present a problem for geoheritage as, although unique and impressive, they can be too extensive to consider as 'sites'.

It is also important from a geological conservation perspective that planners 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 Louth. A lack of awareness in the past has led to the loss of important geological sites and local character throughout the country, e.g. Some very significant Quaternary deposits which rested within Mell Quarry. In Louth a full Landscape Characterisation Assessment was completed in 2002. This provides a tool for planners to help maintain the character of the County.

There are large contrasts in the management requirements for geological sites in comparison to biological sites. Geological features are typically 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 relevant planning department to be aware of the sites and, more generally, that consultation can take place if some development is proposed for a site**. In this way, geologists may get the opportunity to learn more about a site or area by recording and sample collection of temporary exposures, or to influence the design so that access to exposures of rock is maintained for the future, or occasionally to prevent completely inappropriate developments through a strong scientific case.

In other counties, working quarries may have been listed simply because they are the best representative sections available of specific rock sequences, in areas where exposure is otherwise poor. No restriction is sought on the legitimate operation of these quarries. However, maintenance of exposure after quarry closure is generally sought with the operator and planning authority in such a case. At present, several features that host working quarries, are now included as County Geological Sites in Louth. These issues are briefly explored in a set of Geological Heritage Guidelines for the Extractive Industry, issued jointly by the GSI and the Irish Concrete Federation in 2008.

A new quarry may open a new window into the rocks below and reveal significant or particularly interesting features such as pockets of fossils or minerals, or perhaps a karstic depression or cave. Equally a quarry that has finished working may become more relevant as a geological heritage site at that stage in its life. It would possibly need regular maintenance to prevent overgrowth of vegetation obscuring the scientific interest.

Nationally, 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 controlled. However, Louth's sites are not likely to require such an approach. It should be noted that within the European and Global Geopark Network (GGN), there are some self-imposed and self-regulated, quite restrictive, rules relating to the collection and sale of geological specimens, which would apply (for as long as they are maintained by the GGN) to sites within any future Mournes, Cooley and Gullion Global Geopark area.

Waste dumping

An occasional problem throughout the country, including in County Louth, is the dumping of rubbish in the countryside. The dumping of waste is not only unsightly and messy, but when waste materials are dumped in area where rock is exposed, such as quarries or karstic depressions, they may leach into the groundwater table as they degrade. This can cause groundwater pollution and can affect nearby drinking water supplies in wells or springs. Groundwater Protection Schemes (DELG 1999) help to combat pollution risks to groundwater by zoning the entire land surface within counties into different levels of groundwater vulnerability. Such a scheme was completed for Louth County Council by the Geological Survey of Ireland in 2009, thus ranking the county land surface into vulnerability categories of 'Extreme', 'High', 'Moderate' and 'Low', and helps planners in assessing which developments are suitable in some areas of Louth and which are not.

New exposures in development

One less obvious area where the Local Authority can play a key role in the promotion and protection of geology is in the case of new roads. **Wherever major new carriageways are to be built,** or in other major infrastructural work, it should be a policy within the Planning Department, **where new rock exposures are created, that they be left open and exposed** unless geotechnical safety issues arise (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 difficult to change. However, it leads to sterile and uninteresting roads which look the same throughout the country. Leaving rock outcrops exposed where they are intersected along the road improves the character and interest of the route by reflecting the geology and landscape of the locality. Sympathetic tree or shrub planting can still be done, 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. This 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. 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. Initially it was largely a European Geoparks Network (EGN) but has now expanded worldwide as the Global Geoparks Network (GGN) since 2004 and is fully assisted by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) [see www.globalgeopark.org and www.europeangeoparks.org]. A fundamental theoretical 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 three members of the Geoparks Network. One is the cross-border Marble Arch Caves Global Geopark in Fermanagh and Cavan [see www.marblearchcaves.net]. Another is the Copper Coast Geopark in Waterford [see www.coppercoastgeopark.com]. A recent addition has been the Burren and Cliffs of Moher in County Clare [see www.burrenconnect.ie/geopark]. In addition there are aspirant groups exploring the work and infrastructure required for applications in other areas such as Joyce's Country in Mayo and Galway, and the Iveragh Peninsula Kerry group.

The planned application of the Mourne Mountains and Carlingford area as a Mournes, Cooley and Gullion Geopark is solidly founded upon support from Louth County Council and its counterparts in Northern Ireland. Mournes, Cooley, Gullion Geotourism is already promoting the 'brand', organising geo-events and providing geotourism training. This development work required to establish a sustainable Geopark is being funded through the European Union's INTERREG IVA Cross-border Programme managed by the Special EU Programmes Body. It is envisaged that this audit report and the site reports will contribute significantly to the eventual application for Geopark status.

Proposals and ideas for promotion of geological heritage in Louth

The clear and significant inclusion of geological heritage in the County Louth Heritage Plan 2007-2011 was a most welcome and positive step, for a topic that is often undervalued and poorly known in the wider community. This section examines the selected points in the plan relating to geological heritage and provides specific suggestions of how these may be implemented, supported or enhanced by the audit of geological heritage sites in the county.

KPA 1: Primary data acquisition and management

Identify all existing sources of heritage information relating to Louth, especially data collected and held by local and national voluntary bodies and NGOs.
Audit Action: This action is supported by the geological heritage audit, addressing an identified gap in knowledge of Louth's heritage.

Built heritage

3 Carry out a condition survey of all 'statue-type' public memorials.
Audit Action: This action may be supported by the geological heritage audit, since geology provided most of the materials for stone memorials and may help provide data on sources and conservation.

KPA 2: Interpretation and increased public involvement and awareness

All aspects

Make heritage information more easily accessible to non-specialists (ordinary people, including school-teachers and school-children). Focus primarily on interesting, unusual 'anecdotes', eg produce a compendium, perhaps a leaflet or booklet, of interesting information "fifty fascinating facts about Louth's heritage" – that can be added to after time.
Audit Action: This action may be supported by the geological heritage audit, since some geological site or story may be featured.

Develop a Louth Heritage Communications Strategy, for promoting the county's heritage in general, to include, for example:

- *email newsletters*
- *quarterly paper newsletters*
- *lectures and guided tours*
- *outreach programmes for the County archive and museum*
- *leaflets*
- *booklets*
- *press releases/coverage*
- *regular coverage of heritage issues on local radio*
- *shops' fliers*

with events making a contribution too and
a clearly identifiable Louth Heritage Logo.

Audit Action: This action may be supported by the geological heritage audit, since material from the audit and associated exhibition etc has the potential to contribute interesting news or stories for any of these modes of communication.

Make all heritage information available on a web-basis too, not just as physical documents. With e-mapping – all "heritage sites" should be searchable through Internet –GIS.

Audit Action: The audit will provide shapefiles of sites with metadata, primarily for the GIS within the Planning Department. However, all may be easily applied to heritage mapping.

Provide clear and easily-accessible information and advice on the various heritage designations, targeted particularly at developers, who need and want this information.

Audit Action: This action will be fulfilled in relation to geological heritage by the audit, since boundary data will be added to improve previous point data for some sites on the Geological Survey's own web mapping which is an essential data set for developers to consult. In addition new sites and rejected sites will mean that such mapping is up-to-date.

Develop a strategic heritage education plan/outreach programme for Louth, for all ages.

Audit Action: The audit may contribute to this when more fully fleshed out.

Develop local education resources, highlighting local, visitable example sites etc.

Audit Action: The audit could definitely provide resources which allow partial implementation of this action, especially in clarifying visitable geological sites, and appropriateness of sites for different level groups.

Provide heritage training induction courses for all new (and, eventually, existing) staff and councillors. Tell new staff (including planners) what is most important and let them know how they can find out more for themselves, when they need it.

Audit Action: The audit authors could contribute directly to future training courses giving presentations or field trips to planners or councillors or other staff groups (such as NPWS Conservation Rangers).

Set up an outreach scheme for farmers (Built & Natural)
Inform farmers about all important and protected heritage (Built and Natural) on their land (see also 32).

Audit Action: These two actions may be supported by the geological heritage audit, if suitable articles explaining County Geological Sites and geological heritage in general can be provided to and published in farming publications or other channels.

Develop a natural heritage/wildlife/geology interpretation strategy for the county. Promote biodiversity in general and protected sites in particular to the public and school children.

Audit Action: This action may be supported by the geological heritage audit, since geology interpretation can be focused on the most suitable sites, and where public access is without constraints, or can be readily negotiated.

KPA 3: Improving current practice

Develop a Heritage Plan for the Boyne Valley, in partnership with Meath County Council. Assess the implementation of the Integrated Development Plan produced in 1996.

Audit Action: This action may be supported by the geological heritage audit, since a number of sites around Drogheda and Collon have been identified therein.

Produce a Coastal Zone/Floodplain Management Plan, to promote a strategic approach to coastal zone management, sea level rise, coastal protection, retreat.

Audit Action: This action should be informed by the geological heritage audit, since some sites are coastal and should not be compromised by, for example, coastal defence rock armour without consultation on any measure and the specific site(s). Advice may be provided on appropriate geological and geomorphological experts whom should be included in the development of such a plan.

Develop a Special Landscapes Protection and Management Policy. Assess selected landscapes/areas of countryside that require protection and management and investigate mechanisms for achieving this. Maintain a watching brief across the border regarding proposals to develop a Mournes National Park.

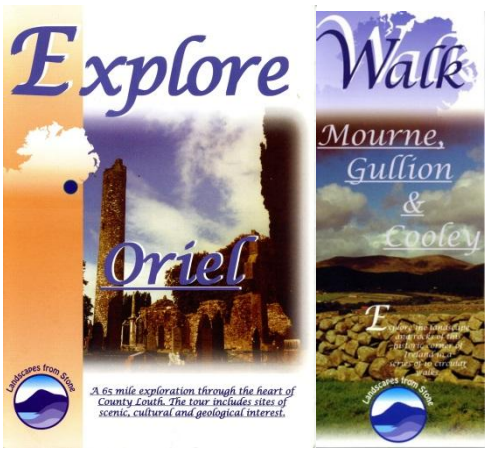
Audit Action: This action may be supported by the geological heritage audit, since a cluster of geological heritage sites may be significant within a selected landscape area.

Develop a scheme to protect minor biodiversity sites i.e. wildlife and habitats which will never be designated at a National or International level, involving purchase, management agreements and a protective designation for county level sites.

Audit Action: The geological heritage audit may provide data on complementary geological heritage sites which should also be treated this way.

Specific ideas for projects

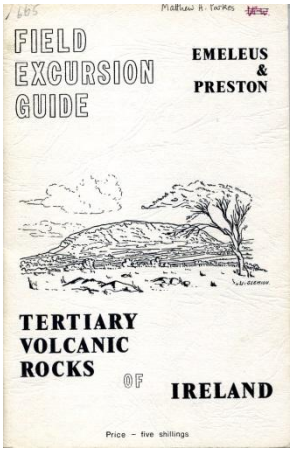
Leaflets



A project called ‘Landscapes from Stone’, run jointly between the GSI and The Geological Survey of Northern Ireland produced a series of walking and driving guides as leaflets in the year 2000. For Louth, *Walk Mourne, Gullion and Cooley, Explore Oriel* and *Explore Mourne, Gullion and Cooley* remain in print. These are non-technical and broader in scope than just geology. There is plenty of scope for other and different leaflets.

Guides

There is an older (1969) but still very useful fieldguide to Tertiary Volcanic Rocks of Ireland by Emeleus and Preston, which includes many sites in Carlingford. More recently in 2008 an excellent geological field guide to Cooley, Gullion, Mourne & Slieve Croob was produced by Louth County Council, written by Sadhbh Baxter. Aside from these there are few existing guides to the geology of County Louth, apart from literature produced within the geotourism projects funded through Interreg schemes. There is scope for guides at different levels of detail and accessibility to non-specialists. A wide 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. **It is suggested that with only modest editing and reorganisation the content of this report would comprise a good general guide to the geological heritage of County Louth, in a broadly similar style to those books produced in Sligo, Meath, Fingal, Waterford and Roscommon following audits.**



Signboards
Simple explanatory or interpretive signboards may be advisable at key 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. The Planning Section should clearly have a controlling input, in conjunction with the Heritage Office. It is most likely that a panel combining various heritage interests at a place is preferred to single interest panels. It is important to consult with potential partners in the planning stage so that duplication does not occur.

The subject of panels, and the integration of text and graphics are a fine art to complete successfully, and the IGH Programme can offer input if signs are planned for key visitor localities. The authors of this report are also able to write, review or provide content on geological heritage for any proposed panels.

One site that could be significant for signs, if it was opened up to the public, is Mell Quarry. There are numerous karstic features in the limestone rock faces that could readily be explained with a signed trail around the quarry if the political will and vision was there to envisage the old quarry as a fantastic public space within the limits of the town of Drogheda. The pure amenity for walks, and the wildlife interest could be enhanced with local history as well as the pure geological heritage interest.

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 research covering human dependence on geology and resources, an interesting exhibition can be put together for display in the Dundalk Museum, Council offices or County Library branches. The model followed was that produced for Carlow, Dun Laoghaire-Rathdown and Waterford. Images of these and others can be seen on the geological heritage section of the GSI website [www.gsi.ie].

New media
There are increasing numbers of examples of new methods of promoting Earth Sciences, via mobile phone applications and other electronic media. Self guiding apps on specific sites would be one of these, such as those produced by Ingenious Ireland for Dublin city geology and for other sites. Plans for such products would require some considerable effort to produce and imaginative effort, with the sites being scattered across the county. The most likely achievement of this type of resource will be through a targeted project for the Mourne, Cooley and Gullion proposed Geopark with some INTERREG funding, utilising talent on the media side with experienced geological education input to produce worthwhile resources, which should stand the test of time.

Earth Science Ireland Group and magazine [www.earthscienceireland.org]
The group Earth Science Ireland is an all-Ireland group promoting awareness of Earth sciences and supporting educational provision in the subject. A main vehicle for the efforts is the twice a year magazine *Earth Science Ireland* and this is distributed free to thousands of individuals, schools, museums, centres and organisations. The editors would welcome more material from the Republic of Ireland and on Louth's geological heritage. It is anticipated by the authors of this report that they will contribute a summary article distilled from the audit report.

Geoschol website [www.geoschol.com]
Geoschol is an educational project, now essentially represented by a website, which was largely aimed at producing educational materials on geology for primary schools. A four page pdf summarising the geology and some highlights of Louth is already part of the available material (see Appendix 6). Working links to the Heritage section of Louth County Council's website, and to other heritage websites, should be established.

Geological Heritage/Geopark Research Archive
If the Heritage Officer wanted to do something similar to that produced in the Burren and Cliffs of Moher Geopark, with downloadable or links to free access papers, then a lot of groundwork is already provided by the reference lists in this audit. Making available technical references of direct relevance to Louth geology and geomorphology will assist many users and researchers into the future.

A summary of the Geology of Louth

1) Paragraph summary

Louth's geological history comprises four main stories. The oldest rocks are ocean floor sediments from a time when Ireland was in two widely separated halves. The ocean closed by plate tectonic movement and stitched the two halves together during the Ordovician and Silurian periods, between 500 and 400 million years ago. Silurian sediments underlie most of the county, with occasional volcanic island rocks seen near Collon for example. The folding seen at Clogher Head shows how these sediments were all crumpled up together. Small areas of Carboniferous Limestone from about 340 million years ago are found around Drogheda, Ardee. Around 65 million years ago, the Atlantic Ocean started opening up and volcanic activity occurred. The Carlingford Peninsula has many volcanic rocks such as basalts that erupted at surface and gabbros that were originally magma chambers deep below ground. The final landscape shape was sculpted by ice sheets during the Ice Age, and by the deposition of glacial till and sediments throughout the county. These are especially well exposed in coastal cliffs around Dundalk Bay.

AGE (Million Years Ago)	*ERA*	*PERIOD*	*EVENTS IN LOUTH (non-italics)*	*IF THIS TIMESCALE WAS A DAY LONG ...*
2.6	Cenozoic	Quaternary	Several ice ages smothering Louth, followed in the last 10,000 years by the spread of vegetation, growth of bogs and arrival of humans. Deposition of drumlins and ribbed moraines, and moulding of crag-and-tails. Extensive sands and gravels deposited when the ice melted, along the Cooley Peninsula.	The ice ages would begin 38 seconds before midnight
66		Tertiary	Erosion, especially of limestone. Caves, cavities and underground streams developing in the limestones around Drogheda.	The Tertiary period begins at 11.40 pm
145	Mesozoic	*Cretaceous*	*Erosion.* *No record of rocks of this age in Louth.*	11.15 pm
201		*Jurassic*	*Uplift and erosion.* *No record of rocks of this age in Louth.*	The age of the dinosaurs, starting at 10.55 pm
252		*Triassic*	*Desert conditions on land.* *No record of rocks of this age in Louth.*	10.42 pm
298	Palaeozoic	*Permian*		10.30 pm
359		Carboniferous	Land became submerged, limestones with some shales and sandstones deposited in tropical seas across the southern portion of the Cooley Peninsula, around Ardee, and around Drogheda. Limestones remaining today are pure and unbedded around Drogheda, with muddier limestones dominant elsewhere.	A significant portion of Monaghan's current rocks (limestone and shale) deposited around 10.10 pm
419		Devonian	*Caledonian mountain building.* Granites intruded into the Cooley Mountains.	9.52 pm
443		Silurian	Shallow seas, following closure of the Iapetus Ocean. Slates, greywacke and shales deposited across the majority of County Louth.	Starts at 9.42 pm
485		Ordovician	Slates, siltstones and volcanic rocks form across the area around Collon.	Begins at 9.28 pm
541		*Cambrian*	*Opening of the Iapetus Ocean.* *No record of rocks of this age in Louth.*	Starts at 9.11 pm
2500	Proterozoic	*Precambrian*	*Some of Irelands oldest rocks deposited in Mayo and Sligo.*	Beginning 11.00 am
4000	Archaean		*Oldest known rocks on Earth.*	Beginning 3.00 am
4600			*Age of the Earth.*	Beginning 1 second after midnight

The Geological Timescale and County Louth

2) Simple summary

The bedrock geology of Louth can be broadly subdivided into three units. The oldest rocks, of the Lower Palaeozoic era, are 440–460 million years old (Ma) and comprise metamorphosed sedimentary and volcanic rocks that underlie most of the county between Dundalk and Drogheda. Younger, Upper Palaeozoic limestones (300–330 Ma) form a small belt on the north side of Drogheda, another around Ardee and also underlie the southern and eastern coastal lowlands of the Cooley Peninsula. The youngest rocks are basalts, gabbros and granites of the Palaeogene (c. 58 Ma) that form the bedrock in the mountains of the Cooley Peninsula.

The sedimentary and volcanic rocks were deposited during the Ordovician (445-460 million years ago, Ma) and Silurian (440-445 Ma) periods when the area was part of the ancient Iapetus Ocean. The Iapetus lay between two continents, the one to the north comprising rocks that today underlie Scotland, north America and the north of Ireland, the other, to the south, incorporating the rest of Ireland, England, Wales and Europe. The Iapetus was a deep ocean and the sediments deposited along its margins and within it form the sandstones and finer-grained mudrocks that today account for most of the bedrock in Louth. The Iapetus Ocean began to close during the Ordovician as a consequence of plate tectonic movements that led to subduction of the ocean floor beneath the continents. This led in turn to the development of volcanic arcs along the continental margins and within the ocean. Volcanic rocks that form the bedrock around Grangegeeth, between Collon and Navan, are the remnants in Louth of these volcanic arcs.

As the ocean closed at the end of the Silurian, the opposing continents eventually collided, leading to the Caledonian orogeny, an event that had a profound effect on the geology of Ireland. The orogeny was a period of mountain building that involved intrusion of granite into the continental crust as well as widespread, intense deformation and metamorphism of the existing Lower Palaeozoic rocks. In Louth, the rocks that formed on the Iapetus sea floor were gradually pushed up against the northern continent into a series of slices parallel to the continental margin, visible today as the northeast-southwest-trending belts of rock that run across the county. Deformation gave rise to compression of the rocks, evident today in the intense cleavage present in most metasedimentary and metavolcanic rocks and in the small- and large-scale folding visible throughout the county.

The period immediately following the Caledonian orogeny is not represented in Louth. In the Lower Carboniferous (specifically Dinantian) period, around 300–330Ma, Ireland was covered by shallow tropical seas and large thicknesses of limestone were deposited, today forming the bedrock to much of the central plain. A relatively thin sequence of limestone is exposed north of the River Boyne in and around Drogheda while the northeastern extremity of the thick Lower Carboniferous rock sequences forms the bedrock at Ardee. However, the most extensive deposits of limestone in Louth underlie the coastal lowlands along the southern and eastern parts of the Cooley Peninsula.

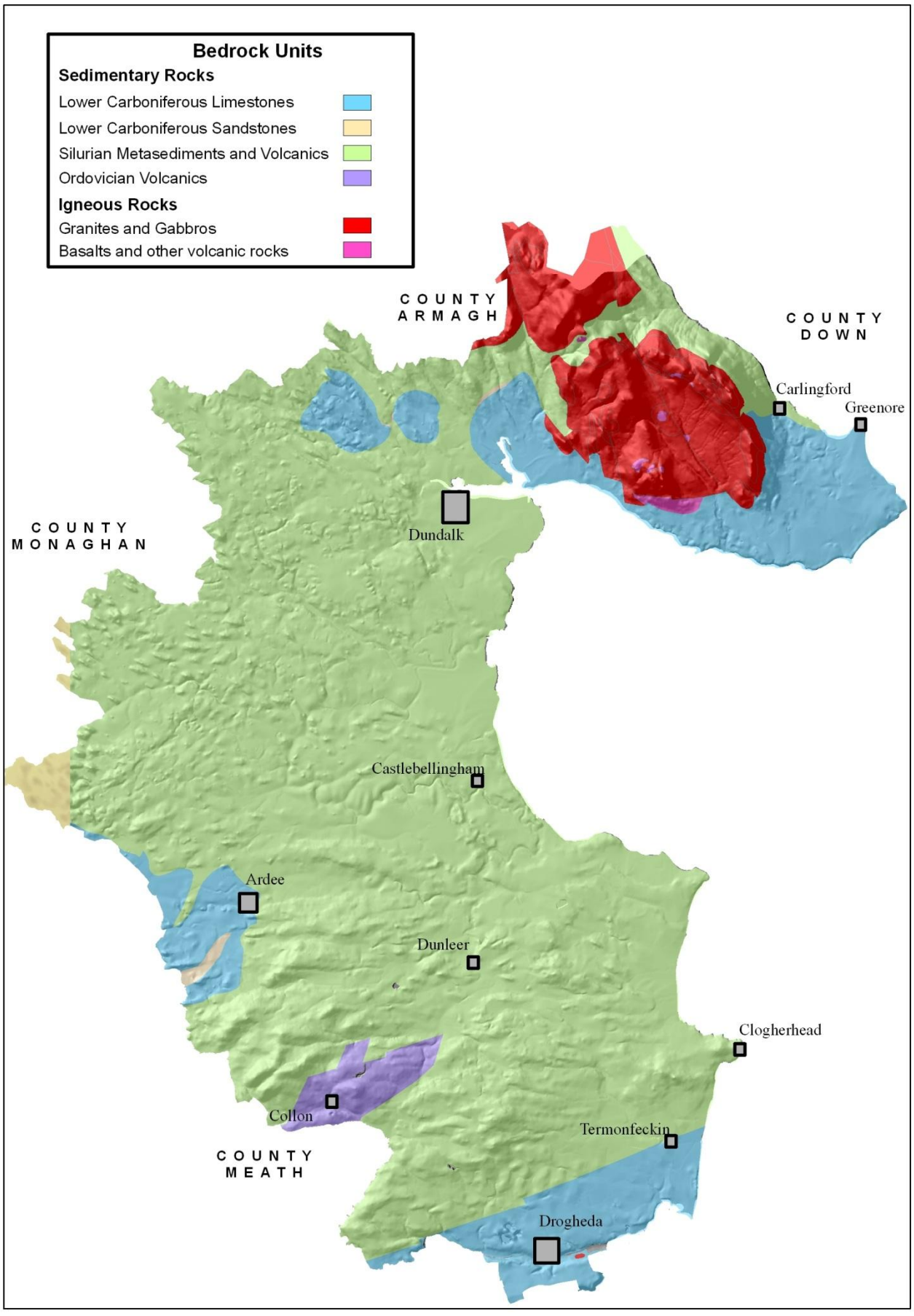
The succeeding 250 million years or so have left no trace in the bedrock of Louth but at the beginning of the Palaeogene period, around 60Ma, northeast Ireland was a place of intense volcanic activity that led to the eruption of huge flows of lava that are today part of the bedrock between the northern coast of Antrim and the Cooley Peninsula. Deeper in the crust, in the volcanic feeder zones, large-scale intrusions of gabbro and granite were formed. Today these form the igneous complexes of the Mourne Mountains, Slieve Gullion

and the mountain areas of the Cooley Peninsula, where the Carlingford Igneous Complex displays spectacular examples of basic and acid intrusions.

In places the limestone exposed at Mell Quarry near Drogheda has been deeply weathered. Various fissures and potholes exposed by quarrying were found to contain pockets of pale clay quite different from the glacial 'boulder clay' on the surface. The clays are thought to be from the Cenozoic Era, between 65 and about 3 million years ago, but attempts to date them using microfossils have failed.

Much of the low ground across Co Louth is blanketed with glacial deposits left behind by glaciers from the last Ice Age. Glacial till, or 'boulder clay', forms some of the rapidly eroding coastal cliffs, particularly at Dunany Point on the south side of Dundalk Bay. Other fine exposures are seen at Giles Quay and Cooley Point on the Cooley Peninsula. The entire county was moulded by ice, with many crag and tails and drumlins forming the hilly ground around the county the remains of the ice sheet deposits. In the major river valleys, when the ice sheets began to melt, wide meltwater rivers were formed, meaning extensive sands and gravels occur along the Boyne Dee, Glyde and Mattock Rives. Other sand and gravel deposits that record this meltwater deposition include the Bush Delta near Rampark on the Cooley Peninsula, and the extensive gravels found around Rathcor, Kilsaran and Castlebellingham.

At the end of glaciation, the land of Ireland rose as relative sea level dropped, owing to a lift in the country afforded by the weight of the ice having been removed when it melted. Raised beaches are common along the Louth Coast, at Templetown, Greenore, Port and Termonfeckin, and record this process. In the Holocene Period, since glaciation, extensive mudflats have formed at the edge of the modern day beaches throughout the area of Dundalk Bay. As well as this, river erosion has occurred along the major rivers in the county, and peat has formed in the Cooley Mountains and in small bog and wetlands around Ardee, Darver and Dromiskin.



A simplified geology map of Louth outlining the main geological units.

Geological heritage versus geological hazards

Ireland is generally considered to be a country with very low risk of major geological hazards: there are no active volcanoes, Ireland's location on stable tectonic plates mean earthquakes are relatively rare and its recorded human history is not peppered with disastrous landslides, mudflows or other geological catastrophes. There are of course risks of one-off events and this section briefly looks at the specific record and nature of geological hazards in Louth and the relationship of the County Geological Sites to those hazards.

The difference between human timescales and geological timescales can be difficult to comprehend but, for many geological processes, there are periods of sudden activity encompassing major events, and then quiet periods in between. The sites in this audit represent evidence of past geological environments and processes, such as tropical coral seas, swampy deltas, volcanic eruption, glacier erosion of the land surface and so on. However, a few sites represent the active geomorphological or land-forming processes of today. These sites, generally coastal in county Louth, are dynamic environments and can be subject to constant or intermittent, sometimes sudden, change.

Landslides and bog flows
In the past decade the Geological Survey of Ireland has been compiling national data on landslides of all types. Louth has a record of remarkably few with only one event recorded.

Flooding
There are two types of flooding which need consideration.

River flooding occurs inland when the rainfall exceeds the capacity of the ground to absorb moisture, and the river channels cannot adequately discharge it to the sea. The OPW website, www.floods.ie, can be consulted for details of individual flood events in County Louth. Some 133 events are recorded across the entire county (as of October 2013). Many of these are in urban settings where rainfall exceeds the capacity of the local drains.

Karstic flooding can occur when underground passages are unable to absorb high rainfall events. Louth has little significant karst or known caves, so this is not an issue for the county.

Groundwater pollution
Whilst not such an obvious hazard as physical collapses, flooding and landslides, the pollution of groundwater supplies carries a serious risk to human health. Large groundwater supplies such as at Ballymakenny and Carlongford require Source Protection Plans, which have been delineated for them by the GSI and the EPA.

Glossary of geological terms

Geological term	Definition
Adit	a horizontal or only gently inclined mine tunnel dug to access coal or mineral ore, or to drain, ventilate or further develop a mine.
Alluvial Deposit	unconsolidated clay, silt, sand and gravel, deposited by a body of running water.
Alluvium	a term for unconsolidated clay, silt, sand and gravel, deposited by a body of running water.
Aquifer	a water saturated rock unit.
Bedding Plane	the contact between individual beds of rock.
Bedrock	a general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material.
Biostratigraphy	using fossils to define the succession of rocks.
Blanket Bogs	bog covering a large, fairly horizontal area, which depends on high rainfall or high humidity, rather than local water sources for its supply of moisture.
Boulder Clay	unconsolidated, unsorted glacial deposits consisting of boulders and cobbles mixed with very finely ground-up rock or silt. Also known as till.
Brachiopods	a marine invertebrate of the phylum Brachiopoda - a type of shellfish. 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.
Bryozoa	invertebrates belonging to the phylum Bryozoa, ranging from Ordovician to present, often found as frond-like, net-like or stick-like fossils.
Calcareous	containing significant calcium carbonate.
Calcite	a pale mineral composed of calcium carbonate, which reacts with dilute acid.
Carbonate	a rock (or mineral), most commonly limestone (calcite) and dolomite.
Cave	a natural underground space large enough for a human to enter, which is usually formed in either soluble limestone by karstic processes, or in exposed rock along the coastline, where the sea erodes natural rock fractures.
Clast	an individual constituent, grain or fragment of a sediment or rock, usually produced by mechanical weathering (disintegration) of a larger rock mass.
Cleavage	a finely spaced, flat plane of breakage caused by compressive deformation of rocks. e.g. the splitting of slate.
Conglomerate	sedimentary rock comprising of 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).
Cross-bedding	layering in sedimentary rocks at an inclined angle to bedding formed by current-ripples.
Crust	the outermost, solid, layer of the Earth.
Delta	a usually triangular alluvial deposit at the mouth of a river, or a similar deposit at the mouth of a tidal inlet, caused by tidal currents.
Dip/dipping	when sedimentary strata are not horizontal they are dipping in a direction and the angle between horizontal and the inclined plane is measured as the dip of the strata or beds.
Dolomite	calcium and magnesium bearing carbonate mineral; also a rock composed of the mineral.
Drumlin	a streamlined mound of glacial drift, rounded or elongated in the direction of the original flow of ice.

Erratic	a rock fragment, often large, that has been transported, usually by ice, and deposited some distance from its source. It therefore generally differs from the underlying bedrock, the name "erratic" referring to the errant location of such boulders. Tracing their source can yield important information about glacial movements.
Facies	the character of the rock derived from its original sedimentary environment and process of deposition.
Fan	a usually triangular deposit of sand and gravel deposited by a glacial stream, either under a lake or under air.
Fault	planar fracture in rocks across which there has been some displacement or movement.
Fault Zone	a tabular volume containing many faults and fault rocks (rocks broken up by fault movement).
Fauna	collective term used to group all animal life.
Floodplain	a flat or nearly flat land area adjacent to a stream or river that experiences occasional or periodic flooding.
Fluvial	pertaining to a river or stream.
Fold(ing)	flexure in layered rocks caused by compression.
Formation	a formal term for a sequence of related rock types differing significantly from adjacent sequences.
Fossiliferous	rich in fossils.
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 prehistorical time.
Glacial	of or relating to the presence and activities of ice or glaciers.
Grading	a sorting effect with the coarsest material at the base of the bed and finest grained material at the top.
Granite	a coarsely crystalline intrusive igneous rock composed mostly of quartz and feldspar.
Greywacke	an impure sandstone, characterised by poorly-sorted, angular grains in a muddy matrix, that was deposited rapidly by turbidity currents (submarine avalanches).
Gully	a deep valley created by running water eroding sharply into bedrock or subsoil.
Haematite	a mineral form of iron oxide, which is the main ore mined as iron.
Horizon	may refer to a single layer of rock such as a coal seam, an ash layer, or other geological 'event'.
Hummock	a small hill or knoll in the landscape, which may be formed by many different processes.
Ice margin	the edge of an ice sheet or glacier.
Igneous	a rock or mineral that solidified from molten or partially molten material i.e. from a magma.
Interglacial	the time interval between glacial stages, or pertaining to this time.
Irish Sea Till	clay-rich till found along the eastern seaboard of Ireland, and occurring as much as 12km inland, which was deposited by an ice stream which occupied the Irish Sea Basin during the last glaciation.
Joint	a fracture in a rock, which shows no evidence of displacement.
Kame-kettle	an irregularly shaped hill or mound composed of sand, gravel and till that accumulates in a depression on a retreating glacier, and is then deposited on the land surface with further melting of the glacier. Kames are often associated with kettles, and this is referred to as *kame and kettle* topography.
Karst	general term used for landscapes formed by weathering of soluble rocks, usually limestone, by surface water and/or groundwater.

Kettle hole	a shallow, sediment-filled body of water formed by retreating glaciers or draining floodwaters.
Knoll	a small hill or hillock sticking up from generally flat terrain.
Laminated	the finest example of stratification or bedding, typically exhibited by shales and fine-grained sandstones.
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.
Lodgement	process by which debris is released from the sliding base of a moving glacier/ice sheet and plastered or 'lodged' onto the glacier bed; also describes tills emplaced by this process (i.e. lodgement till).
Melt-out	process by which glacial debris is very slowly released from ice that is not sliding or deforming internally; also describes tills emplaced by this process (i.e. melt-out till).
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.
Misfit stream	a stream which is too small to have eroded the valley in which it flows, as is often the case with streams now flowing in meltwater channels.
Moraine	any glacially formed accumulation of unconsolidated debris, in glaciated regions, such as during an ice age.
Mudmound	Waulsortian limestone of Carboniferous age is characterised by forming as massive mounds or ridges or sheets of carbonate mud on the seafloor of the time. Mudmound is a general term to describe the varieties of forms.
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.
Ore	a mineral which is concentrated enough to be exploited by mining.
Orogeny	the creation of a mountain belt as a result of tectonic activity.
Outcrop	part of a geologic formation or structure that appears at the surface of the Earth.
Periglacial	very cold but non-glacial climatic conditions.
Plate Tectonics	a theory that states that the crust is divided up into a number of plates, whose pattern of horizontal movement is controlled by the interaction of these plates at their boundaries with one another.
Pyrite	iron sulphide, pale yellow/gold coloured mineral, commonly occurring as cubes and often called 'fool's gold'.
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.
Sedimentary	a rock formed by the deposition of sediment, or pertaining to the process of sedimentation.
Shaft	a vertical hole dug in a mine for access, ventilation, for hauling ore out or for pumping water out.
Shale	a very fine-grained mudstone, containing quartz and clay minerals, that splits easily along the plane of bedding.
Siltstone	is similar to mudstone but with a predominance of silt-sized (slightly coarser) particles.
Sink	another name for a swallow hole, the point where a stream passes underground.
Slumping	the movement of a mass of unconsolidated sediment or rock layers down a

	slope, or pertaining to contorted sedimentary bedding features.
Solution pipe	a karstic feature of solution in a vertical narrow chimney or pipe shape.
Spring	the point where an underground stream reaches the surface.
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 (zone)	the sudden sinking or gradual downward settling of the Earth's surface with little or no horizontal movement.
Swallow hole	the point where a stream passes underground, sinking below the ground surface.
Terrestrial	pertaining to the Earth's dry land.
Till	unconsolidated, unsorted glacial deposits consisting of boulders and cobbles mixed with very finely ground-up rock as sand, silt or clay also known as boulder clay.
Transgression	an incursion of the sea over land area.
Trilobites	extinct arthropods.
Turbidite	deposit of a turbidity current.
Turbidity Current	underwater density current carrying suspended sediment at high speed down a subaqueous slope. The resulting deposit is called a turbidite.
Unconformable	a sedimentary rock that is not following in sequence from the one below but has a significant time gap present between them.
Unconformity	a buried erosion surface separating two rock masses or strata of different ages, indicating that sediment deposition was not continuous.
Vadose Zone	the area between the surface and the water table.
Vein quartz	white thin veins of quartz injected in rock fractures during episodes of stress. Also found as durable beach pebbles, once it has been eroded.
Volcanic Rock	any rock produced from volcanic material, e.g. ash, lava.
Volcaniclastic	rock material was derived from a volcanic eruption, but the rock was deposited as a sedimentary rock like a sandstone, as an aggregate of small particles.
Volcanism	the process by which magma and its associated gasses rise into the crust and are extruded onto the Earth's surface and into the atmosphere.
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 Louth

This section is a brief summary of relevant GSI datasets, to assist any enquiry concerning geology and to target possible information easily. The GSI has very many datasets, accumulated since it began mapping Ireland's geology in 1845. A Document Management System (DMS) is freely available to any person at the GSI Customer Centre, 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 print-outs can be made or data supplied on CD, or via USB keys etc. **Data is available free of charge**. It is planned to make this resource available online but no date is yet set for when this may be achieved, although many subsets are already available within online data.

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. Parts of Sheets 8/9 and 13 include Louth.

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.

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 parts of Sheets 60, 70, 71, 81, 82, 91 and 92 cover County Louth. Each sheet or several sheets were accompanied by a Memoir which described the geology of that area in some detail. These still provide valuable records of observations even though interpretations may have changed with better geological understanding. Memoirs are in the Customer Centre library and scanned on the DMS.

Historical geological mapping is now available via a website: http://www.geologicalmaps.net/irishhistmaps/history.cfm

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.

MinLocs Data

The MinLocs Database records all known mineral occurrences, however small, from GSI records, such as 19th century fieldsheets and Open File data.

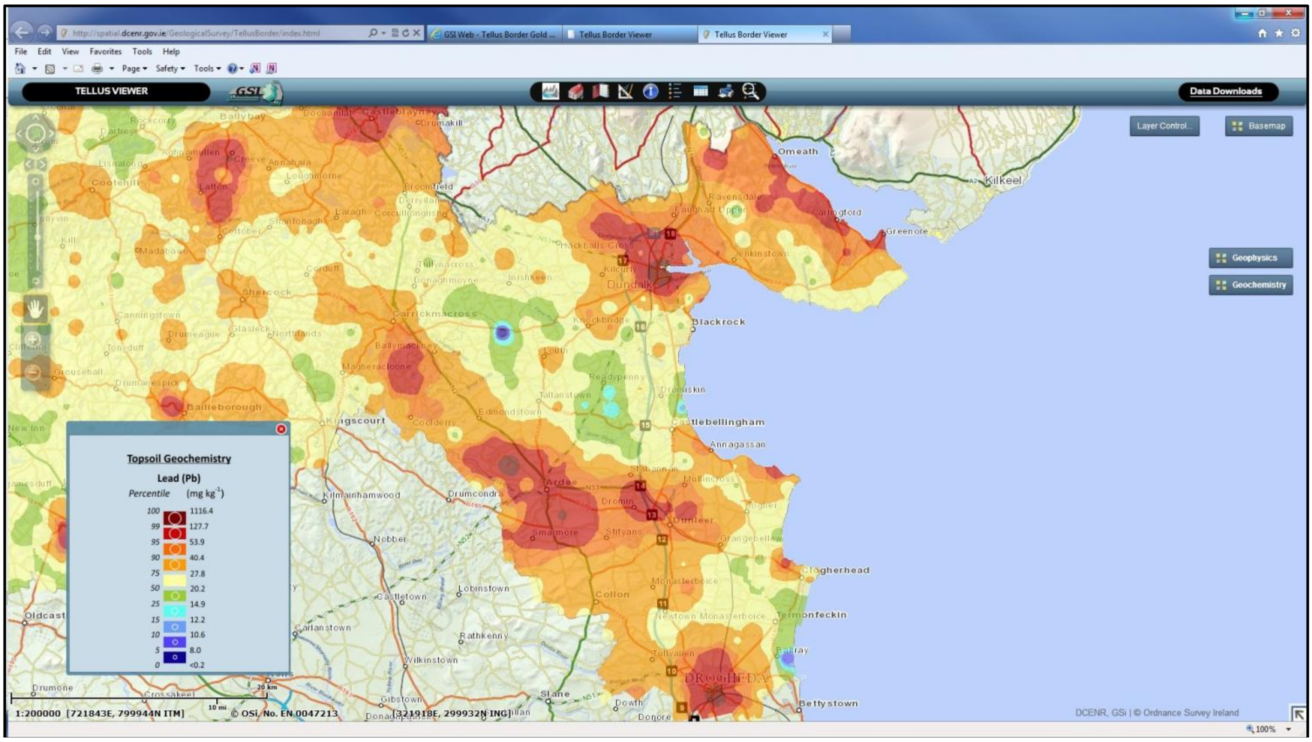
Historic Mine Records

Abandonment plans and varied other material exists for the various mining ventures in the country, but there is very little for Louth other than a lead and copper prospect at Salterstown.

Subsoils Mapping
Since a Groundwater Protection Scheme has been completed for County Louth by GSI, a recently completed map of the subsoil types and depths across Louth exists, as well as the previously completed bedrock mapping. This provides a significant resource in general terms as well as for groundwater protection. Customised output is possible. Further more detailed compilation of glacial geology datasets, including a revision to be published by GSI in late-2013, will provide more options in the near future.

Digital mapping of many different datasets is now available via the GSI website: www.gsi.ie

Tellus Border Data
A very significant project undertaken over the last few years has been the Tellus Border project, in which enormous amounts of systematic data on geophysics and geochemistry of the border counties with Northern Ireland (including Louth) has been gathered, extending the information gathered in Northern Ireland as part of the original Tellus Project. The GSI is one of 4 partners, and the project was funded under INTERREG IVA Programme. Airborne and ground based survey systematically gathered data on over 50 elements. This will have applications in environmental, health, mineral exploration and other areas. Public access to data from the project was launched on the 24th October 2013, and results will flow as analysis and research into the data proceeds. This project has its own website: www.tellusborder.eu



View of the TELLUS map of lead concentrations in topsoil across County Louth, as seen on the TELLUS map viewer at www.gsi.ie. See the high concentrations around Dundalk, Ardee and Drogheda, as well as on the Cooley Peninsula.

Shortlist of Key Geological References

This reference list includes a few **key** papers, books and articles on the geology and geomorphology of Louth that are recommended as access points to Louth's fabulous geological heritage.

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Full Geological references

See Appendix 2 for the full reference list of all papers, books, articles and some unpublished reports etc relating to the geology and geomorphology of Louth that could be traced.

Mining heritage references

Appendix 2 includes some references specifically pertaining to the mining heritage of County Louth. Assistance with locating these references may be provided by the Mining Heritage Trust of Ireland if required.

Quaternary References

The references in Appendix 3 are all covering the Quaternary, or Ice Age, geology of Louth. They are split into the specific ones covering Louth sites or features and a section of national or regional papers with some Louth data included.

Further sources of information and contacts

Sarah Gatley of the Geological Survey of Ireland, who is the Head of the Geological Heritage and Planning Section, can be contacted in relation to any aspect of this report. Brendan McSherry, the Heritage Officer of Louth County Council is the primary local contact for further information in relation to this report. Other contacts include the Conservation Rangers of the National Parks and Wildlife Service, currently in the Department of Arts, Heritage and the Gaeltacht. The names and phone numbers of current staff may be found in the phone book, or at www.npws.ie.

Web sites of interest

www.gsi.ie - for general geological resources
www.geology.ie – the website of the Irish Geological Association who run fieldtrips and lectures for members, including many amateur enthusiasts
www.earthscienceireland.org - for general geological information of wide interest [this website address is likely to change in 2012/2013. Suggestion search for 'Earth Science Ireland']
http://www.iqua.ie - for information, fieldtrips, lectures etc in relation to Ireland's Ice Age history
http://www.cavingireland.org/ - for information on caves and safe caving
http://www.progeo.se/ - for information about ProGEO the European Association for the Conservation of Geological Heritage

Acknowledgements

The authors would like to gratefully acknowledge the assistance of Brendan McSherry, Heritage Officer from Louth County Council in the development of this project. Funding from the Heritage Council and Louth County Council is also acknowledged. We also acknowledge the many members of the IGH Programme Expert Panels who helped define the sites which were considered for County Geological Site status. Lastly, we especially thank those landowners, quarry operators and others who allowed or facilitated access to sites. Brendan McSherry is thanked for an instructive audit visit to Mell Quarry in Drogheda, and Vincent Toner who arranged access.

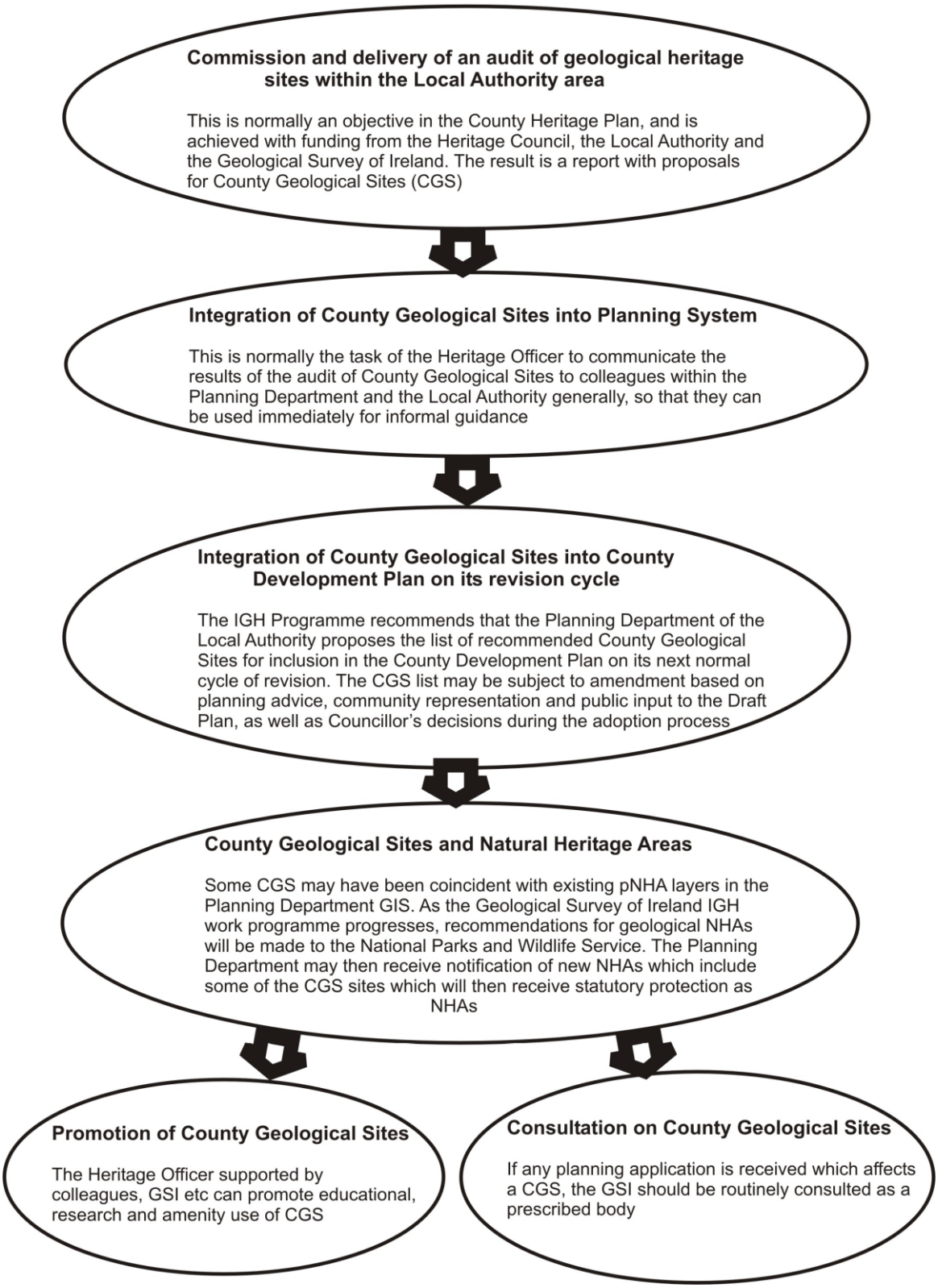
Appendix 1 – Geological heritage audits and the planning process

This appendix contains more detail on the legal framework behind geological heritage audits conducted by County Councils, and the process which operates as a partnership between the Geological Heritage and Planning Section of the GSI and the local authority Heritage Officer.

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; First Schedule Condition 21], Planning and Development Regulations 2001, Wildlife (Amendment) Act 2000 (enabling Natural Heritage Areas) and the Heritage Act 1995. The Planning and Development Act and the Planning Regulations in particular, place responsibility upon Local Authorities to ensure that geological heritage is protected. Implementation of the Heritage Act 1995, through Heritage Officers and Heritage Plans, and the National Heritage Plan 2002, allow County Geological Sites to be integrated into County Development Plans.

The chart below illustrates the essential process, established by the Irish Geological Heritage Programme in the GSI, over the course of numerous county audits since 2004.

County Geological Sites - a step by step guide



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Appendix 4 - Rejected sites

A range of sites had been previously flagged for consideration in the IGH Master site list, and some were assessed as unsuitable for County Geological Site status in this audit. Similarly a range of additional sites were assessed in the audit, based on the authors' expert knowledge of Louth's geology. Other sites were visited on spec during fieldwork. The rejected sites are listed below with brief notes as to why they were assessed as unsuitable for inclusion.

Drakestown Quarry

This site was initially proposed as of interest for the IGH8 Lower Carboniferous theme, primarily for well developed sedimentary features. It has also been noted as an ASI (#5 for Louth) by An Foras Forbartha. However, there is virtually no rock exposed in the low quarry walls and it is exceptionally overgrown with vegetation. Whilst some potential interest exists, should all the vegetation be removed, the vagueness of previous data as to the type, scale and extent of sedimentary features is not encouraging. Additionally, based on discussions with nearby residents, there have been considerable difficulties over ownership of the quarry and due to construction of a housing estate along the ridge of limestone, there is little likelihood of any future reopening that might expose the rocks again. Two extant limekilns adjacent to the fenced off entrance area are of more interest than the quarry itself. It is also possible that the sedimentary cements of scientific interest were found in a quarry on thesouthern side of the road which is now totally removed and remodelled as a car park.

Ardee Moraine Ridges

The ridges west of Ardee, along the northern and southern sides of the N33 road, were interpreted as moraine ridges by Marshall McCabe in 1972. Recent work by Clark and Meehan (2001) and Greenwood and Clark (2009) have shown that these are in fact drumlins, just like many of the other drumlins present across mid and western County Louth. From this, they are not of any special scientific interest.

Cloughmore Erratic

The Cloughmore Erratic as defined and grid referenced in the IGH Master Site List is actually in County Down.

Castlebellingham Shore

The Castlebellingham Shore as defined and grid referenced in the IGH Master Site List refers to a raised beach deposit, which when mapped out on the ground is restricted in extent. Given that impressive and extensive raised beaches at Greenore, Port and Templetown have been designated as County Geological Sites as part of this audit, the inclusion of a small, narrow and less recognisable feature, just because it exists, might devalue the process itself.

Tullyallen/Mell Quarry

The exposure into the Mell Formation, which is an exposure of glacio- marine sediments and two tills in Mell Quarry in Drogheda, has now been covered with landfill and sediment along the northern side of the quarry. Though the site was of major importance in the 1970's in the estimation of sea-levels during the Ice Age, the site is now completely obliterated and therefore the locality has no conservation status in a Quaternary, or Ice Age, sense.

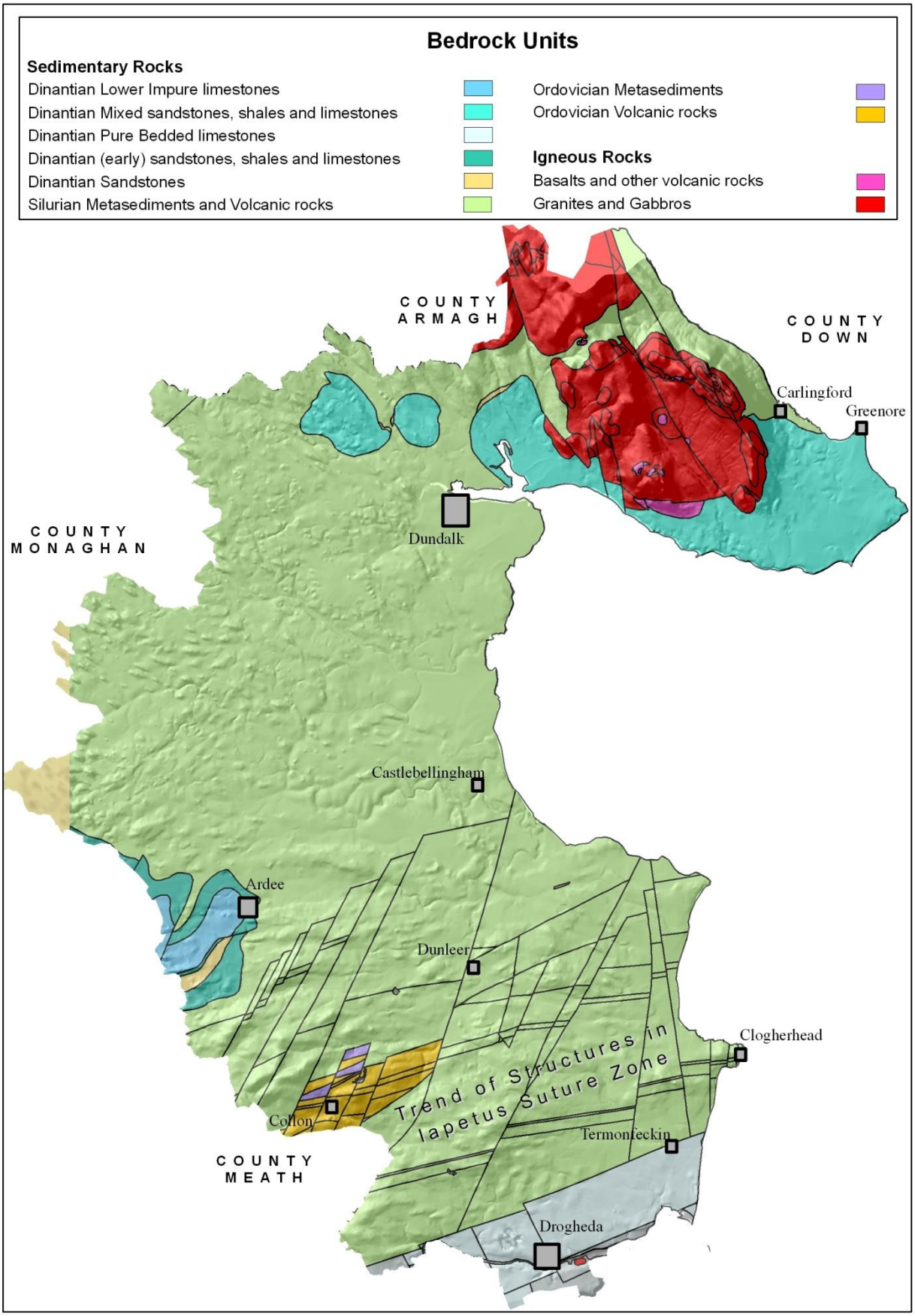
Rosemount Quarry

The main interest here lies in the cone sheets and dykes that remain after extensive quarrying of the limestone. The limestone itself, despite its proximity to the main granophyric microgranite intrusion of the Carlingford Complex, is relatively unmetamorphosed and contains well-displayed fossils. Unfortunately, the quarry is almost completely overgrown. Access is difficult, particularly in summer, because of the extensive, thick growth of brambles, gorse, trees, etc. The exposures that remain, when accessible, are relatively small in size and of poor quality. There are numerous, excellently exposed examples of cone sheets and dykes in the Carlingford area, notably at King John's Castle, Windy Gap and Barnavave Site B, and there is no evidence to suggests those in Rosemount Quarry are of any greater significance or merit. Given this, the poor exposure and difficulty of access, this site is not recommended for CGS status.

Trumpet Hill

Trumpet Hill is one of two main locations where the early-stage gabbros of the Carlingford Igneous Complex are exposed. The other is Drumenagh Quarry, 500m northeast. The gabbro was sampled by O'Connor (1990) as part of his strontium isotope study of the Palaeogene igneous intrusions of northeast Ireland. However, the hill is now extensively covered by a mature forest and access to exposure, chiefly around the summit of the hill, is difficult. The privately-owned forest is regularly used for mountain biking events. Far better, and more readily accessible, exposure is found in nearby Drumenagh Quarry. For this reason, Trumpet Hill is not considered suitable as a CGS.

Appendix 5 - A detailed geological map of County Louth



Appendix 6 - Geoschol leaflet on the geology of County Louth

LOUTH

AREA OF COUNTY: 820 square kilometres or 316 square miles

COUNTY TOWN: Dundalk

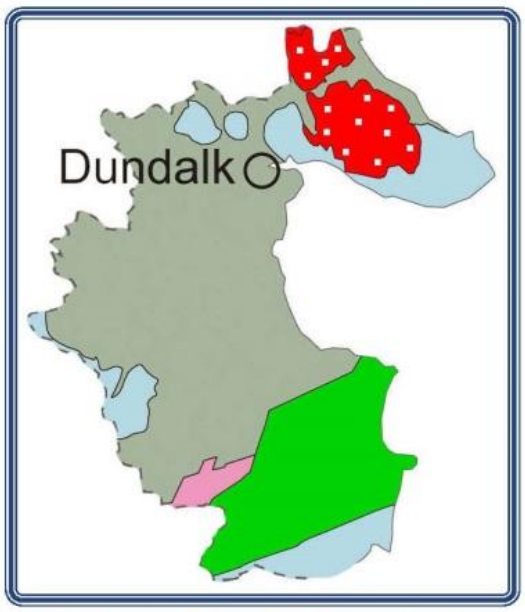
OTHER TOWNS: Ardee, Carlingford, Drogheda, Dunleer

GEOLOGY HIGHLIGHTS: Silurian ocean floor at Clogher Head; Paleocene volcanics on the Cooley Peninsula

AGE OF ROCKS: Ordovician, Silurian, Carboniferous, Paleogene, Pleistocene

Clogher Head

Steeply tilted beds of mudstone and muddy sandstone (known as 'greywacke') form the craggy cliffs and shore.



Geological Map of County Louth

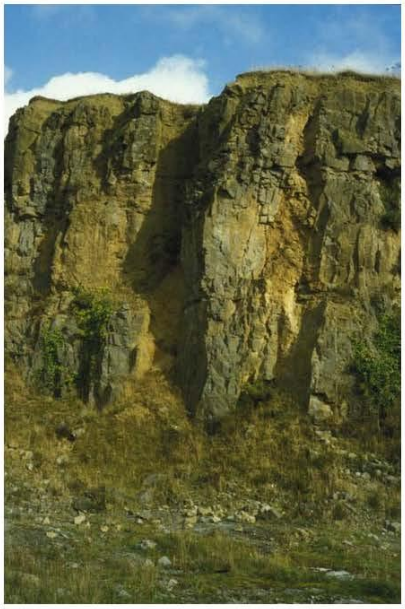
Pink: Ordovician; **Green:** Silurian; **Grey:** Ordovician & Silurian sediments; **Red:** Granite; Light blue: Lower Carboniferous limestone; **Flecked Red:** Paleogene Gabbros and other intrusive rocks.

Geological history

The imposing hills of the Cooley Peninsula, in the north-east of the county rise steeply above Dundalk Bay and overlook a more subdued landscape stretching across the rest of Co. Louth.

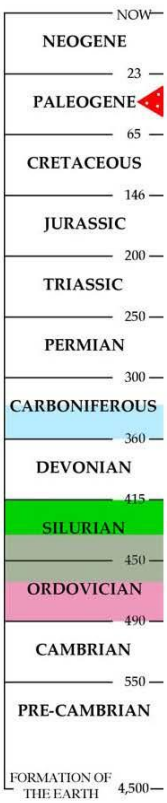
The oldest rocks form a low range of hills just a few kilometres to the north-west of Drogheda, but they are poorly exposed. These Ordovician rocks, around 465 to 450 million years old, are dominated by volcanic lavas and ash falls erupted from volcanic islands and deposited on the ocean floor. Much of the low ground in the north of the county, between Dundalk and Ardee, is underlain by Silurian rocks, around 440 to 425 million years old. These were deposited on a deep ocean floor, where layers of slowly deposited dark mud were periodically interrupted by influxes of muddy sand avalanching down into the ocean basin from shallower water. Later, as the continental plates either side of this ocean moved together, these interbedded layers

The deeply weathered Carboniferous limestone in Tullyallen Quarry contains pockets of clay which are believed to be perhaps thirty million years old.



of mudstone and sandstone became buckled and broken. Today these ancient ocean floor sediments, tilted almost vertical, are superbly exposed in the coastal cliffs at Clogher Head.

There are a few rather small areas of Carboniferous limestone to the north of Dundalk, around Drogheda, and to the west of Ardee. These rocks, deposited on an equatorial sea bed around 340 million years ago, for the most part go unnoticed although they were formerly worked in a large quarry at Tullyallen, just to the north of Drogheda.



Geological timescale showing age of rocks in Louth.

In places the limestone exposed at Tullyallen has been deeply weathered. Various fissures and potholes exposed by quarrying were found to contain pockets of pale clay quite different from the glacial 'boulder clay' on the surface. The clays are thought to be from the Cenozoic Era, between 65 and about 3 million years ago, but attempts to date them using microfossils has failed.

Although the age of the clays at Tullyallen remains unproven, the rocks that form the hills of the Cooley Peninsula undoubtedly are Cenozoic. All are volcanic and are Paleocene in age, around 60 million years old. They include basalt lava flows that erupted onto the surface as well as more coarsely crystalline gabbros that cooled in a magma chamber beneath the volcano. These gabbros form the mountain of Slieve Foye, the highest point in the county.

Much of the low ground across Co Louth is blanketed with glacial deposits left behind by glaciers from the last Ice Age.

Slieve Foye rises dramatically above the town of Carlingford. The dark gabbros of which it is made cooled slowly, producing large crystals, in the magma chamber below a volcano.

Glacial till, or 'boulder clay', forms some of the rapidly eroding coastal cliffs, particularly at Dunany Point on the south side of Dundalk Bay.

Mining & Building Stones

The standing stones around the 5000 year old passage tomb at Newgrange were quarried from the Silurian sandstones exposed at Clogher Head. Today similar Silurian sandstone is quarried for aggregate near Dunleer. The limestone quarried at Tullyallen was used in cement manufacture.

Map adapted with permission from Geological Survey of Ireland 1:1,000,000 map 2003.
Image credits: Mike Simms (all).

Text & images by Mike Simms

Section 2 - Site Reports

Site reports – general points

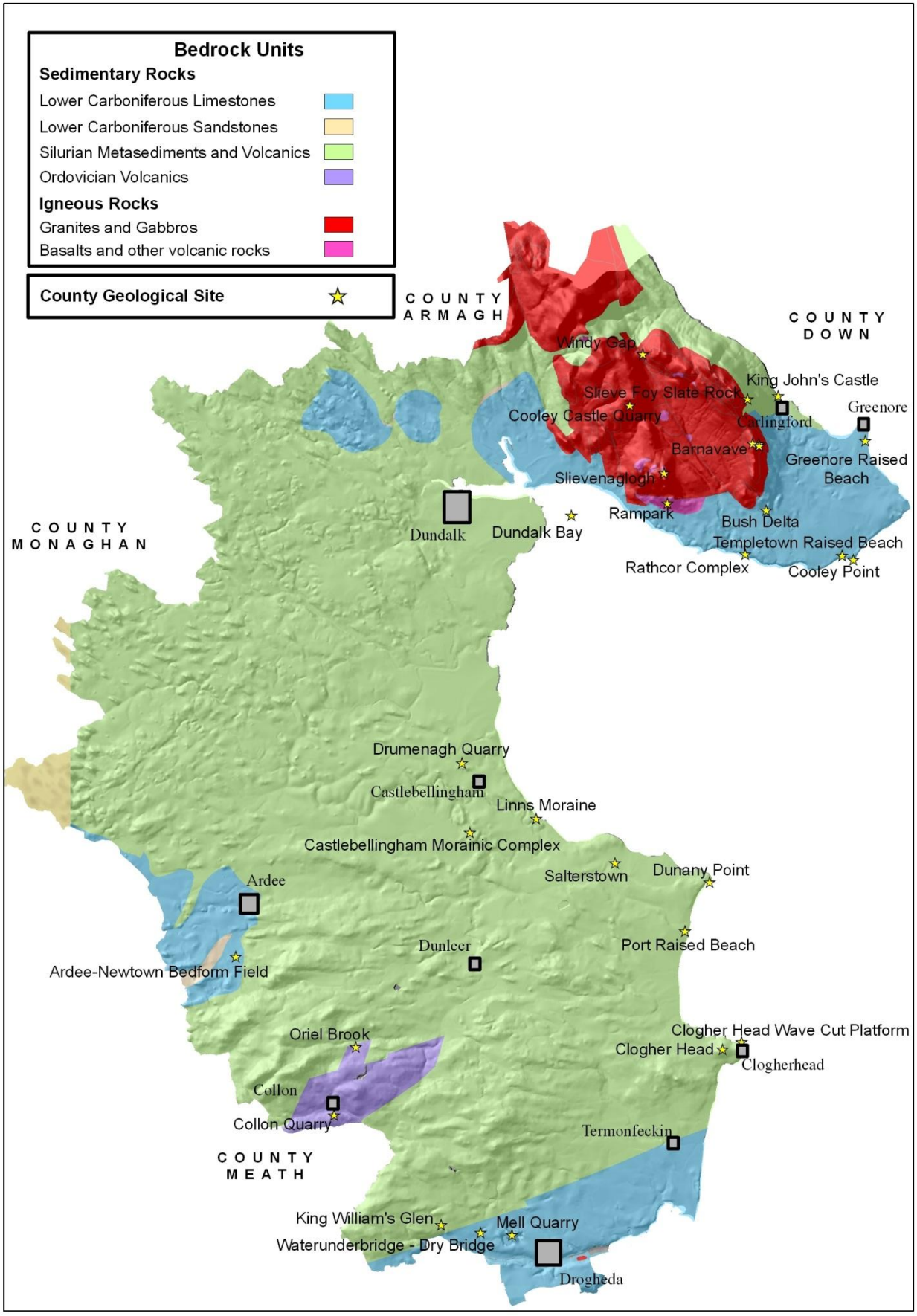
The following site reports are brief non-technical summaries of the proposed County Geological Sites for County Louth. These have been specially prepared for this Report in order to make the information accessible to planners and others without geological training. For most sites more detailed reports 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 some low resolution photographs exemplifying the site. **A CD accompanying this report will include further pictures of most sites at higher resolution, should they be required for a glossy booklet or leaflet for the general public**. Grid references are given normally for a central point in the site, if the site is small, or two extreme points at opposite ends of the site if the site is extensive or linear. They are only indicative of the location, but the site extent is best shown on the included maps. Irish Transverse Mercator (ITM), which is the geographic projection co-ordinate system for Ireland, is used to describe all site localities in each of the site reports.

A series of maps are provided with an outline of the site boundary. It is important to note that these boundaries have no legal or definitive basis. They are indicative only of the limits of exposure or of geological interest, and not based on detailed field and boundary surveys, which were outside the scope of this contract. Boundaries are drawn to include the geological or geomorphological interest of the site, but are extended to the nearest mappable boundary, such as a field boundary, stream, road or edge of forestry. On a few sites, such as in open mountain terrain, it is impractical to find a boundary within a reasonable distance and an arbitrary line may be defined. County Geological Sites are non-statutory and so this is not problematic. If any such site is assessed for NHA status in the future, such a boundary may require small revisions.

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. Some areas may already be available if they are proposed NHAs (pNHA), under the Wildlife (Amendment) Act 2000. Areas which have been designated as Special Areas of Conservation (SAC) under European Habitats Directives will also have statutory boundaries already determined. The geological interest may be included within the wider area of nature conservation.

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 most important 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, Head of the Heritage and Planning Section, in the Geological Survey of Ireland, Beggars Bush, Haddington Road, Dublin 4. Phone 01-6782837. Email: sarah.gatley@gsi.ie



Simplified Geological Map of Louth with site locations indicated.