

The Geological Heritage of Monaghan

An audit of County Geological Sites in Monaghan

by Robert Meehan, Vincent Gallagher, Matthew Parkes and Sarah Gatley

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For the:
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Section 2 – Site Reports

IGH 1 Karst

Site Name

Aphuca Cave

Ballyloughan Turloughs

Creevy Cave

Donaghmoyne Rising

Fin McCool's Chair and Kilmactrasna Cave

Moylan Lough

Tiragarvan

Tullyvaragh

IGH 2 Precambrian to Devonian Palaeontology

Site Name

Not represented in Monaghan

IGH 3 Carboniferous to Pliocene Palaeontology

Site name

Mokeeran Quarry

IGH 4 Cambrian-Silurian

Site name

Carrickatee Hill

IGH 5 Precambrian

Site name

Not represented in Monaghan

IGH 6 Mineralogy

Site Name

Calliagh

Clontibret Stream

Lemgare

IGH 7 Quaternary

Site Name

Ballyloughan Turloughs [see IGH 1]

Knocknacran Gypsum Mine

Leeg Drumlin

Moylan Lough [see IGH 1]

Rockcorry-Cootehill ribbed moraines

Scotshouse-Redhills cross-cutting ribbed moraines

IGH 8 Lower Carboniferous

Site Name

Not represented in Monaghan

IGH 9 Upper Carboniferous and Permian

Site Name

Knocknacran Gypsum Mine [see IGH 7]

IGH 10 Devonian

Site Name

Not represented in Monaghan

IGH 11 Igneous intrusions

Site Name

Not represented in Monaghan

IGH 12 Mesozoic and Cenozoic

Site Name

Knocknacran Gypsum Mine [see IGH 7]

IGH 13 Coastal Geomorphology

Site Name

Not represented in Monaghan

IGH 14 Fluvial and lacustrine geomorphology

Site Name

Not represented in Monaghan

IGH 15 Economic Geology

Site Name

Clontibret Stream (see IGH 6)

Hope Mine (Cornalough)

Knocknacran Gypsum Mine [see IGH 7]

Lengare [see IGH 6]

Tamlat

Tassan

IGH 16 Hydrogeology

Site Name

Ballyloughan Turloughs [see IGH 1]

Moylan Lough [see IGH 1]

Report Summary

County Monaghan is not widely known for its geological heritage, yet it has some very fine if underappreciated geological sites. The County Council's support for this audit is critical in raising the profile of geological heritage in Monaghan. The geology of the county is quite diverse and the geological heritage interest extends throughout the county.

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 Monaghan. It proposes them as County Geological Sites (CGS), for inclusion within the Monaghan 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, some 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 have been provisionally notified to the National Parks and Wildlife Service (NPWS) by the GSI for designation as Natural Heritage Areas (NHAs) 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 Monaghan 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 Monaghan remains at the forefront of geological conservation in Ireland.

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 Monaghan County Council. It will also be made available via the County Council website for the people of Monaghan. A chapter of the report includes recommendations on how to best present and promote the geological heritage of Monaghan 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 Monaghan, if the funding can be found to produce it.

Monaghan in the context of Irish Geological Heritage

This report ensures Monaghan remains active at the forefront of geological heritage within Ireland, as it is one of around half of the counties to date which have commissioned such an audit within the scope of the county-based Heritage Plan. It will hopefully encourage the remaining 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. Geodiversity 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 the IGH Programme 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 Monaghan 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 which 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. All these various important sites 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 yet been formally designated, but no sites in Monaghan were considered to be of national importance to be put forward as Natural Heritage Areas (NHA) for those few themes. Therefore, inclusion of all sites as County Geological Sites (CGS) in Monaghan'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, 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 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 often 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, and requires no additional designation of actual land areas, other than citation of the geological interest.

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 stream sections. 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 illustrates the processes that formed it.** The Quaternary theme and the Karst theme often include such sites. In Monaghan, the ribbed moraine landscape that dominates the county is characteristic of the larger sites encompassed under the IGH 7 Quaternary theme. Large areas of Monaghan's landscape are covered by drumlinised ribbed moraine, which can present a problem for geoheritage as, although 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 Monaghan. A lack of awareness in the past, has led to the loss of important geological sites and local character throughout the country. In Monaghan a full Landscape Characterisation Assessment was completed in 2008. This provides a tool for planners to help maintain the character of the County.

There are large differences 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 that the relevant planning department is 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 a completely inappropriate development through presentation of a strong scientific case.

In other counties, working quarries may have been listed 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 in agreement with the operator and planning authority in such a case. At present, working quarries like Mokeeran Quarry are now included as County Geological Sites in Monaghan. These issues

are briefly explored in a set of Geological Heritage Guidelines for the Extractive Industry, published jointly by the GSI and the Irish Concrete Federation in 2008.

A new quarry may open up a 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 may need occasional maintenance to prevent overgrowth of vegetation obscuring the scientific interest, or may be promoted to the public by means of a viewing platform and information panel.

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 opportunity for general collecting may need to be controlled. However, Monaghan's sites are not likely to require such an approach.

Waste dumping

An occasional problem throughout the country, including in County Monaghan, 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 areas where rock is exposed, such as limestone 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 Monaghan County Council by the GSI in 2001, thus ranking the county land surface into vulnerability categories of 'Extreme', 'High', 'Moderate' and 'Low', and helping planners to assess which developments are suitable or not in some areas of Monaghan.

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, that **where new rock exposures are created, they be left open and exposed** unless geotechnical safety issues arise (such as where bedding dips are 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 that 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 costs.

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 of outstanding significance and is used to develop sustainable tourism opportunities**. Initially it was largely a European

Geoparks Network (EGN) but since 2004 has expanded worldwide as the Global Geoparks Network (GGN) 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. The Geopark branding therefore helps promote the geological heritage resource so that the community can benefit from it.

In Ireland there are three members of the Geoparks Network. One is the cross-border Marble Arch Caves Global Geopark in Fermanagh and Cavan [see www.marblearchcaves.net and www.cavancoco.ie/marble-arch-caves-global-geopark]. The Copper Coast Geopark in Waterford also joined the Network in 2001 [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 Country in Mayo and Galway, and the cross-border Mourne-Cooley-Gullion area. At present, despite interesting geological heritage in the county, it is not likely that any area would meet the criteria for a Geopark application.

Proposals and ideas for promotion of geological heritage in Monaghan

The clear and significant inclusion of geological heritage in the County Monaghan Heritage Plan 2012-2017 is a most welcome and positive step, for a topic that is often undervalued and poorly known in the wider community. This section examines the existing points in the plan relating to geological heritage and provides specific suggestions as to how these may be implemented, supported or enhanced by the audit of geological heritage sites in the county.

COLLECTING INFORMATION ON HERITAGE: SURVEY AND INVENTORIES

| REF | ACTION |
|-----|--------|
|-----|--------|

- | | |
|---|--|
| 1 | <i>Conduct a survey to identify and evaluate the surviving historic designed landscapes in County Monaghan and promote the conservation of their built and natural character and heritage.</i> |
|---|--|

Audit Action: This broad action will be supported by the geological heritage audit, since the geological foundation has a strong influence on the natural character of a landscape, and the historic use of building materials was often very localised and dependent upon the geology of the local area.

- | | |
|---|---|
| 2 | <i>Undertake an audit of geological heritage sites within County Monaghan in conjunction with the Geological Survey of Ireland.</i> |
|---|---|

Audit Action: This action is fulfilled by the geological heritage audit.

- | | |
|---|---|
| 4 | <i>Use new technologies such as LIDAR in the survey, analysis and conservation of heritage.</i> |
|---|---|

Audit Action: This action is not directly supported by the audit, but if LIDAR is being used in Monaghan, then consideration should be given to including some geological or geomorphological landscapes in any study. In particular, LIDAR of the area around Carrickmacross may help map and identify many karstic features which have not yet been recorded.

- | | |
|---|--|
| 5 | <i>Work with communities to compile information on holy wells, mass paths, mass rocks and other similar sites.</i> |
|---|--|

Audit Action: This action is contributed to by the site report on Aphuca Cave, which was also the site of a mass rock.

BUILDING CAPACITY: EDUCATION, AWARENESS AND TRAINING

| REF | ACTION |
|-----|--------|
|-----|--------|

- | | |
|----|---|
| 20 | <i>Ensure that heritage sites within the ownership or custodianship of Monaghan County Council are appropriately managed, signposted, interpreted and accessible. Information on these sites will be published.</i> |
|----|---|

Audit Action: None of the sites here are known to be County Council ownership, but if additional sites are proposed in future, or if land ownership changes to the Council, then appropriate signs can be provided.

- | | |
|----|---|
| 24 | <i>Identify associations between historical figures and places or sites in Monaghan, encourage their conservation and make information available accordingly.</i> |
|----|---|

Audit Action: This action may be supported by the geological map and report account of the Quaternary Geology, which provides the background to the formation of the famous 'stony grey soil' of Monaghan, as recalled by Patrick Kavanagh.

26 *Develop a series of heritage booklets and make them available on the internet.*

Audit Action: This action may be supported by the geological heritage audit, since geology is poorly understood and the authors have the potential to create suitable, easily understood booklets and material for dissemination in association with the Heritage Officer.

27 *Publish twice yearly e-newsletter “Monaghan Heritage Matters” and maintain heritage website.*

Audit Action: This action may be supported by the geological heritage audit, since geology is poorly understood and the authors have the potential to contribute articles in association with the Heritage Officer.

29 *Use information collected in heritage plan projects for public awareness, education and training purposes.*

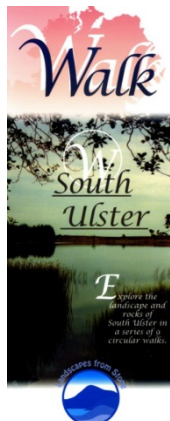
Audit Action: This action may be supported by the geological heritage audit, since geology is poorly understood and the authors have the potential to contribute articles in association with the Heritage Officer. It is envisaged that a simple, largely pictorial exhibition will be delivered in various formats (physical and downloadable for website). The magazine Earth Science Ireland would probably publish a summary article from the audit (as has been done for Waterford and Roscommon). Additional material can be added to the website www.geoschol.com. The audit authors are also open to potential walks, talks, events and similar. As recommended below, if appropriate funds can be earmarked, a public friendly book could be distilled from the audit, in similar fashion to those created recently in Sligo, Meath, Fingal, Waterford and Roscommon. These ideas are discussed in more detail in the following section.

Other audit benefits:

1. Selected geological and speleological titles will be made available digitally to help build the county's heritage data. These will come from the authors' own connections (including Matthew Parkes, the Speleological Union of Ireland Librarian) and resources.

Specific ideas for projects

Leaflets



A project called 'Landscapes from Stone', run jointly between the GSI and The Geological Survey of Northern Ireland (GSNI) produced a series of walking and driving guides as leaflets in the year 2000. For Monaghan, *Walk South Ulster* remains in print. These are non-technical and broader in scope than just geology. There is plenty of scope for other and different leaflets. For example, a leaflet detailing the topography of the county could promote the wonderful drumlinised ribbed moraine landscape which dominates Monaghan. One on the karst features around Carrickmacross is another suggestion. Any leaflets produced could simply be made available as pdf downloads on the Council's website to avoid large costs of printing.

Guides

There are few existing guides to the geology of County Monaghan, apart from some GSI technical literature produced many decades ago. 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 distil into a good general guide to the geological heritage of County Monaghan, in a broadly similar style to those books produced for 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 successful integration of text and graphics on information panels is a fine art, 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.

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 Monaghan County Museum (or one of its outreach venues), Council offices or County Library branches. The model followed was that used for Carlow, Dun Laoghaire-Rathdown and Waterford. Images of those, and other similar ones can be seen on the Geological Heritage/Exhibitions 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 the recently launched app for tourists in the Burren and Cliffs of Moher Geopark. Plans for such products would require some considerable effort to produce and imaginative effort, with the sites being scattered across the county.



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 Monaghan'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 Monaghan is already part of the available material (see Appendix 7). Working links to the Heritage section of Monaghan County Council's website and the Monaghan Heritage Forum's Facebook page, as well as to other heritage websites, should be established.

Geological Heritage 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 Monaghan geology and geomorphology will assist many users and researchers into the future.

A summary of the Geology of Monaghan

1) Paragraph summary

The oldest rocks in Monaghan are Ordovician muddy sandstones, called greywackes, and volcanic lavas. These and Silurian rocks through central and southern Monaghan 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, between 500 and 400 million years ago. In the northern part of the county Carboniferous Limestone and other sediments are present, from about 340 million years ago. Around Carrickmacross is another patch of limestone, with a series of younger rocks from the Permian and Triassic periods including important gypsum deposits. There are also a few deposits exposed of volcanic rocks from the opening of the Atlantic Ocean about 65 million years ago. The final landscape shape was sculpted by ice sheets during the Ice Age, and by the deposition of glacial till in drumlins and as ribbed moraine, right across most of the county.

| AGE (Million Years Ago) | ERA | PERIOD | EVENTS IN MONAGHAN (non-italics) | IF THIS TIMESCALE WAS A DAY LONG ... |
|----------------------------------|-------------|--------------------|---|---|
| 2.6 | Cenozoic | Quaternary | Several ice ages smothering Monaghan, 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. | 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 Carrickmacross. | The Tertiary period begins at 11.40 pm |
| 145 | Mesozoic | <i>Cretaceous</i> | <i>Erosion.</i> <i>No record of rocks of this age in Monaghan.</i> | 11.15 pm |
| 201 | | <i>Jurassic</i> | <i>Uplift and erosion.</i> <i>No record of rocks of this age in Monaghan.</i> | The age of the dinosaurs, starting at 10.55 pm |
| 252 | | Triassic | Desert conditions on land. Sandstones and gypsums deposited between Kingscourt and Carrickmacross. | 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 much of the northern and southern extremes of County Monaghan. Limestones remaining today are pure and unbedded in south Monaghan, with muddier limestones dominant in the northern area. | A significant portion of Monaghan's current rocks (limestone and shale) deposited around 10.10 pm |
| 419 | | <i>Devonian</i> | <i>Caledonian mountain building.</i> <i>No record of rocks of this age in Monaghan.</i> | 9.52 pm |
| 443 | | Silurian | Shallow seas, following closure of the Iapetus Ocean. Slates, greywacke and shales deposited across the southern half of County Monaghan. | Starts at 9.42 pm |
| 485 | | Ordovician | Slates, siltstones and volcanic rocks form across much of the central portion of County Monaghan, between Clontibret and Scotshouse. | Begins at 9.28 pm |
| 541 | | <i>Cambrian</i> | <i>Opening of the Iapetus Ocean.</i> <i>No record of rocks of this age in Monaghan.</i> | Starts at 9.11 pm |
| 2500 | Proterozoic | <i>Precambrian</i> | <i>Some of Ireland's oldest rocks deposited in Mayo and Sligo.</i> | Beginning 11.00 am |
| 4000 | Archaean | | <i>Oldest known rocks on Earth.</i> | Beginning 3.00 am |
| 4600 | | | <i>Age of the Earth.</i> | Beginning 1 second after midnight |

The Geological Timescale and County Monaghan

2) Simple summary

With the exception of the southern slopes of Slieve Beagh, in the extreme northwest of the county, the landscape of Monaghan is low and gently undulating. The oldest rocks form a strip running northeast–southwest across the centre of the county. These Ordovician rocks, around 445 to 460 million years old, consist mostly of mudstone and muddy sandstones, or ‘greywackes’, but include some submarine lavas. They accumulated on the floor of an ocean at a depth of more than 4000 metres. Similar dark mudstones and greywackes of Silurian age, around 440 to 445 million years old, again with some minor submarine volcanic rocks, form a much broader band across much of the southern half of the county.

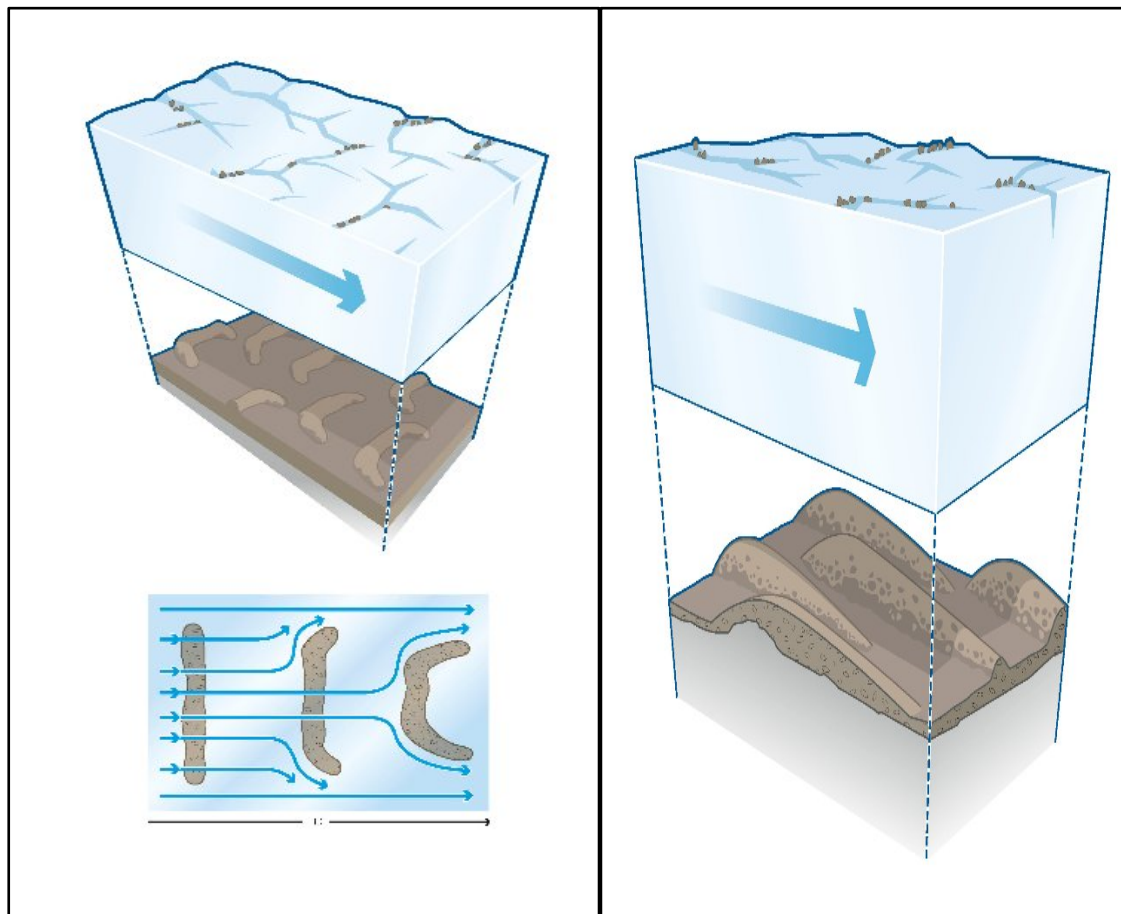
The northern third of the county is underlain by 330–360 million-years-old Carboniferous (specifically Dinantian) age rocks. They are very poorly exposed but boreholes show that the earliest rocks are pebble beds and sandstones overlain by limestones. On the southern slopes of Slieve Beagh, the limestones are overlain by thick mudstones and sandstones. The pebble beds at the base of the Carboniferous succession were deposited in broad shallow rivers. As sea levels rose, the river systems were submerged by lagoons and then by shallow tropical seas, the latter now represented by the limestones. The younger mudstones and sandstones above them were deposited by river deltas encroaching into the sea as sea levels began falling again.

Carboniferous and younger rocks, surrounded by much older Silurian rocks, are found in the extreme southeast of the county where they have subsided along a major tectonic fault. Grey Carboniferous limestones, deposited on a shallow sea floor around 330 million years ago, are overlain by younger Carboniferous sandstones, mudstones and a few thin coal seams, deposited in an Equatorial swamp or delta environment around 320 million years ago. Strikingly different rocks lie above, and to the west of, these Carboniferous rocks. Red mudstones with two gypsum beds up to 35 metres thick are Permian in age, around 255 million years old, while thick red siltstones and sandstones above them are Triassic, slightly less than 250 million years old. Both the Permian and Triassic rocks accumulated on a desert land surface, with gypsum being deposited as saline lakes dried out under the arid conditions.

The youngest rocks in the county lie above, and within, these Permian and Triassic ‘red beds’. They have been observed in the open-cast and underground gypsum mine at Knocknacran. Here, basalt lavas lie above the Permian gypsum beds while dolerite fills the fissures up which the lava travelled to reach the surface, and now forms dykes and sills. These lavas are almost certainly of Palaeogene age, and therefore around 60 million years old, from a time when much of northeastern Ireland was wracked by volcanic activity.

The ice sheets that covered County Monaghan during the last Ice Age have had a profound influence on its present landscape. Most of the low ground is underlain by deep deposits of glacial till, or ‘boulder clay’, obscuring the bedrock geology beneath. Over much of the county this was moulded by the moving ice sheet into ‘drumlinised’ ribbed moraines. Ribbed moraines are large ridges formed perpendicular to ice flow which, in Monaghan, form the largest features formed under an ice sheet anywhere in the world. As well as this, they form the largest field of such features globally, and around Scotshouse the only occurrence worldwide of cross-cutting ribbed moraines is seen. Ribbed moraines are effectively large ‘chains’ of drumlins, which are oriented transverse to ice flow. The name “drumlin”, used internationally, comes from the Irish ‘dromnin’ meaning ‘low hill’. Drumlins are mounds of

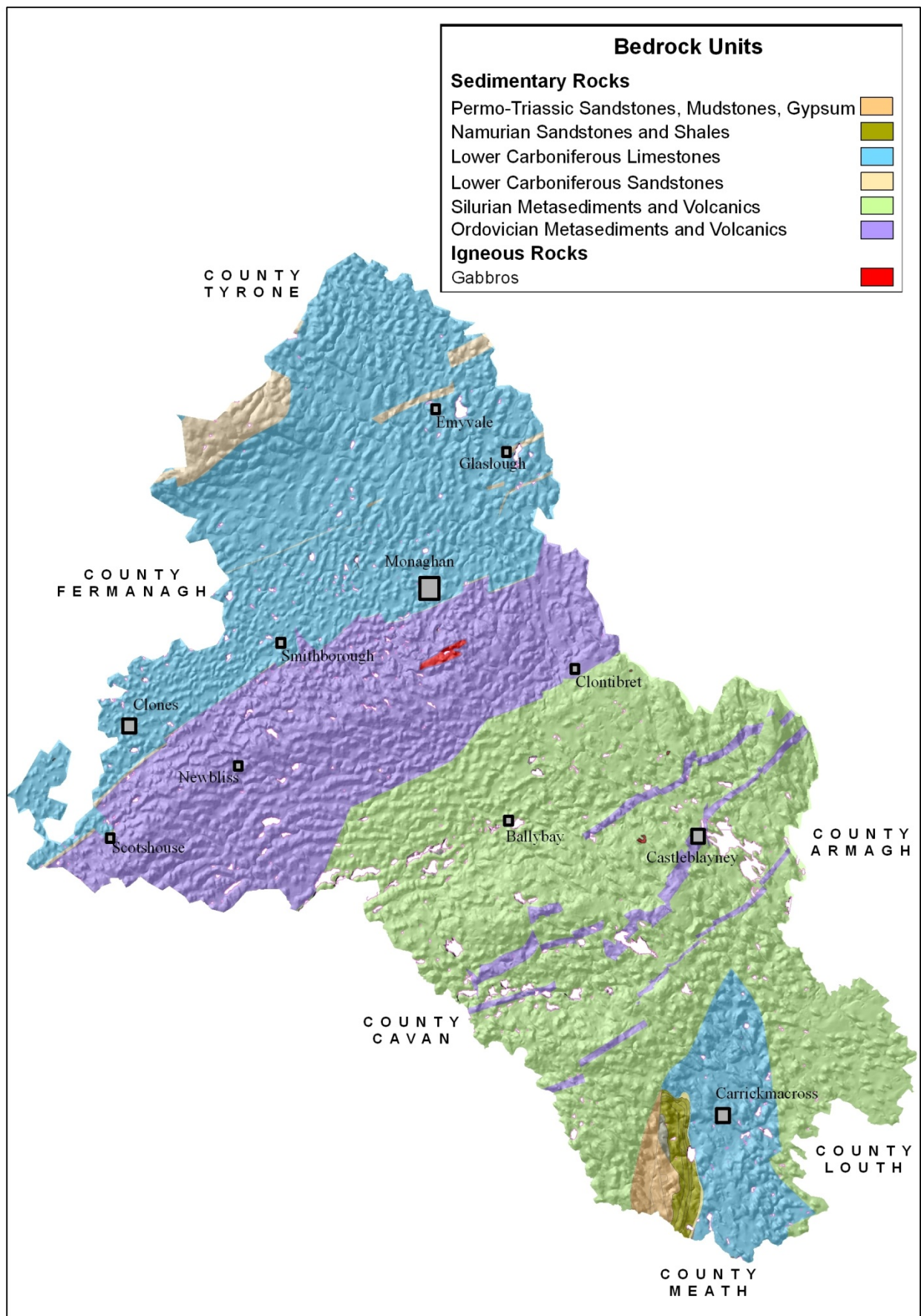
debris left behind by melting ice sheets and are typically streamlined in the direction of ice-sheet flow.



Illustrations showing the formation of ribbed moraines (left) and drumlins (right) under a moving ice sheet.

The ice sheet flowed generally northwest to southeast across Monaghan, a fact illustrated by the orientations of the crag and tails and drumlins, which are aligned northwest to southeast in general.

Since the Ice Age, during the Holocene, the modern drainage pattern was superimposed on the deglacial channel network, meaning some areas of haphazard drainage among the drumlins and ribbed moraines. At this time peat also formed between the drumlin and ribbed moraine ridges.

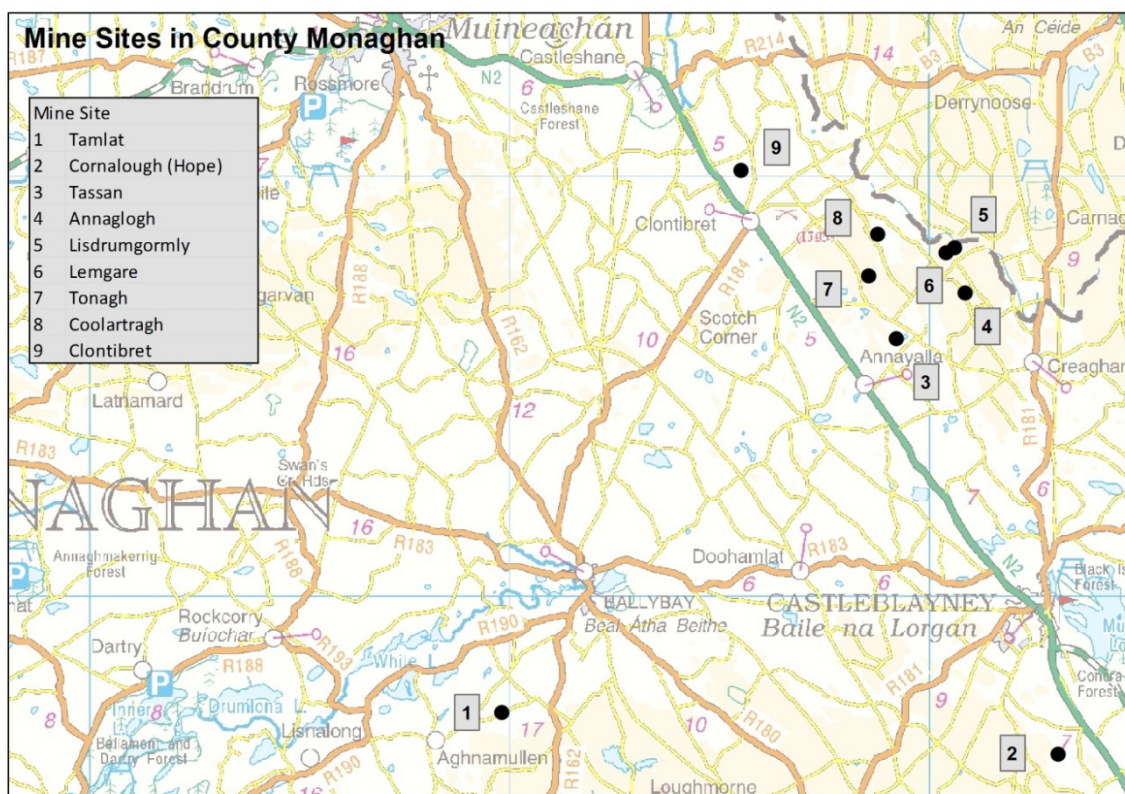


A simplified geology map of Monaghan outlining the main geological units.

Mining in Monaghan

Monaghan has an extensive if perhaps under-appreciated mining history. The first deposit to be developed, around the middle of the 18th century, was probably Tamlat, near Ballybay, where lead was mined briefly from a series of shallow shafts or pits. Morris (1984) suggests that lead mining at this time may have been associated with pottery manufacture and the use of lead in glazes. Antimony was discovered near Clontibret, apparently in the early 1770s (Morris 1984), and was the subject of several attempts at exploitation, the last by the Mining Company of Ireland which developed several shafts and adits in 1825–26 before abandoning it. Several small lead mines were begun in the early-to-mid-1800s, including those at Lisdrumgormly, Annaglogh and Lemgare, but the most productive period for mining in the county was from around 1850 to 1870 when Tassan, Cornalough and Coolartragh were significant producers of lead and silver. Despite subsequent reassessment of various deposits in the early part of the 20th century, including during the First and Second World Wars, it was the discovery in 1956 by the Mining Corporation of Ireland of gold associated with the antimony deposit at Clontibret that rekindled interest in Monaghan's metallic mineral potential and exploration in the years since has defined an extensive zone of low-grade gold mineralization.

Although there are numerous abandoned mine sites in the county, few contain well-preserved surface mine features. Some, such as Coolartragh, now the site of a large quarry, have disappeared entirely or almost so. A few are marked by the presence of derelict buildings, including the notable remains of a Cornish engine house chimney at Cornalough, but in most cases small waste heaps, or mine spoil, and traces of shafts are all that remain. Nevertheless, in aggregate, it is a significant component of the geological heritage of the county with potential for further public promotion.



Mine sites in County Monaghan



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 Monaghan 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 many counties, but mainly karstic or riverine in Monaghan, are dynamic environments and can be subject to constant or intermittent, sometimes sudden, change.

Landslides and bog flows

The Geological Survey of Ireland has been compiling national data on landslides in the past decade. However, there are no records for Monaghan.

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 Monaghan. Some 114 events are recorded across the entire county. Many of these are in urban settings where rainfall exceeds the capacity of the local drains. This type of flooding occurred in March 2013 across much of Monaghan's lowlands.

Karstic flooding can occur when underground passages are unable to absorb high rainfall events. The abundance of springs, swallow holes, river sinks and dolines indicates that there is widespread karstification of limestone in County Monaghan. Some caves have also been noted, specifically around Carrickmacross. However, in sites such as Mokeeran Quarry, the epikarst zone, *i.e.* the zone nearest the surface, is not strongly developed, even though some deep expanded joints and fissures are evident and many of them have clay rich sediment fills. At some sites, such as the swallow hole at Tullyvaragh, water is known to back up and flow overland when rainfall is heavy.

A recent study of wetlands in Monaghan, carried out as an action of the Heritage Plan, has established that there are several previously unrecorded turloughs in Monaghan, such as the County Geological Site at Ballyloughan, listed in this audit. Turloughs are seasonal lakes that reflect seasonal variation in the ground water table, filling when the water table rises and draining when it falls. The normal pattern is for them to be lakes in winter and dry grassland in summer, although localised weather/rainfall patterns may mean they are wet in summer too. Some, like Moylan Lough, probably retain a body of water all year round.

However, changes in water level in turloughs are generally slow and seasonal and do not generally constitute a threat of flooding.

Karstic collapse

This is a real but localised hazard in parts of Monaghan, principally around Carrickmacross, where karstified limestone is typically only a few metres (or less) beneath the land surface. The number of known caves in the limestone is very few but there are other karst features including dolines. Dolines are enclosed depressions that have no surface water drainage associated with them. Some form by slow dissolution of the underlying limestone rock but others can be formed as rapid collapse events. Across the country as a whole, they are often not reported and simply filled in by land owners so we have little information on the frequency with which they occur, including in Monaghan.

In the same area around Carrickmacross, beds of gypsum are found within the local stratigraphy. Gypsum is also soluble and theoretically collapses could occur due to gypsum dissolution. However, although dolines that developed in the gypsum since the last Ice Age have been recorded and studied in Knocknacran open-cast mine, there have been no recorded incidents of collapse and it is not considered likely hazard at surface.

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. Monaghan has several large groundwater supplies, and each have their own risks depending on the cover of protecting sediment above groundwater, and the hazard present within each Zone of Contribution to the boreholes. As the groundwater is largely contained within limestone, it should be noted that karstic springs (such as at the Spring Lake Water Supply, near Carrickmacross) are especially vulnerable to pollution since the flow is mainly within fissure conduits allowing rapid transmission of pollution from source to water supply. The opportunity for microbial attenuation of pollutants is far less in limestone fissures (as there are no natural barriers to stop pollutants) than it would be in granular deposits, which act as natural filters. It would appear that many one-off houses have been built in karstic areas where there is unlikely to have been appropriate percolation rates in subsoils to permit septic tanks to work well. Septic tank outflow pipes have been observed by the authors in a number of dolines and sinkholes in Monaghan, potentially contributing pollution directly to aquifers.

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. |
| Clint | tabular block of limestone in a limestone pavement. |
| Crag and tail | a steep resistant rock mass (crag), with sloping softer sediments (tail) protected from glacial erosion or deposited as glacial debris on the crag's 'downstream' side. |
| 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. |
| Doline | circular/oval closed depression found in karst terrain. |

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| 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. |
| Epikarst | the shallow layer, near surface, of highly karstified rock, with many voids included. |
| 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. |
| Evaporite | a chemical sediment that forms in layers through the evaporation of seawater (or lakes) in arid climates. |
| Facies | the character of the rock derived from its original sedimentary environment and process of deposition. |
| 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. |
| Flowstone | calcite or other minerals deposited as a surface crust by water flowing over cave or mine walls and floors. |
| 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. |
| Gabbro | a dark coarsely crystalline intrusive (plutonic) igneous rock composed mostly of plagioclase feldspar, olivine, pyroxene and amphibole. |
| 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. |
| Greywacke | an impure sandstone, characterised by poorly-sorted, angular grains in a muddy matrix, that was deposited rapidly by turbidity currents (submarine avalanches). |
| Grike | a solutionally widened vertical fracture separating clints on a limestone pavement. |
| Gully | a deep valley created by running water eroding sharply into bedrock or subsoil. |
| Gypsum | a soft evaporite mineral found in clays and limestones, sometimes associated with sulphur. |
| 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. |

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| | from a magma. |
| Interglacial | the time interval between glacial stages, or pertaining to this time. |
| Joint | a fracture in a rock, which shows no evidence of displacement. |
| Karst | general term used for landscapes formed by weathering of soluble rocks, usually limestone, by surface water and/or groundwater. |
| 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). |
| Maze cave | a cave formed in an extensive grid pattern when slow moving water. |
| 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. |
| Phreatic | when a cave passage or void space in limestone rocks is filled with water it is said to be phreatic or in the phreatic. When later found without water in them such passages have a characteristic cylindrical shape from solution in all directions and are called phreatic tubes. |
| Phreatic Zone | the area below the water table, where the rock is completely saturated with water. |
| 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'. |
| Ribbed moraine | a subglacially (i.e. under a glacier or ice sheet) formed type of moraine landform that mainly occurs in Fennoscandia, Scotland, Ireland and Canada. Ribbed moraines cover large areas that were previously overlain by ice and occur mostly in what is believed to have been the central areas |

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| | of the ice sheets. |
| 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. |
| Sandur | a plain formed of glacial sediments deposited by meltwater outwash at the terminus of a glacier. |
| Sedimentary | a rock formed by the deposition of sediment, or pertaining to the process of sedimentation. |
| Shaft | a vertical or inclined 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. |
| Sluggers | a tube-like collapse of the Earth's surface into an underground cavity, which has formed by the dissolution of limestone. |
| 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. |
| Turlough | a seasonal lake that fills and empties through springs and sinkholes. |
| 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, derived from a volcanic eruption, re-deposited as a sedimentary rock, e.g. 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 Monaghan

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. Sheets 8/9 and a small part of Sheet 13 includes Monaghan.

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 46, 57, 58, 59, 69, 70 and 81 cover County Monaghan. 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 county, including those 19th century lead mines in the Castleblayney district, including Lemgare, Annaglogh, Lisdrumgormly, Croaghan and the Hope Mines.

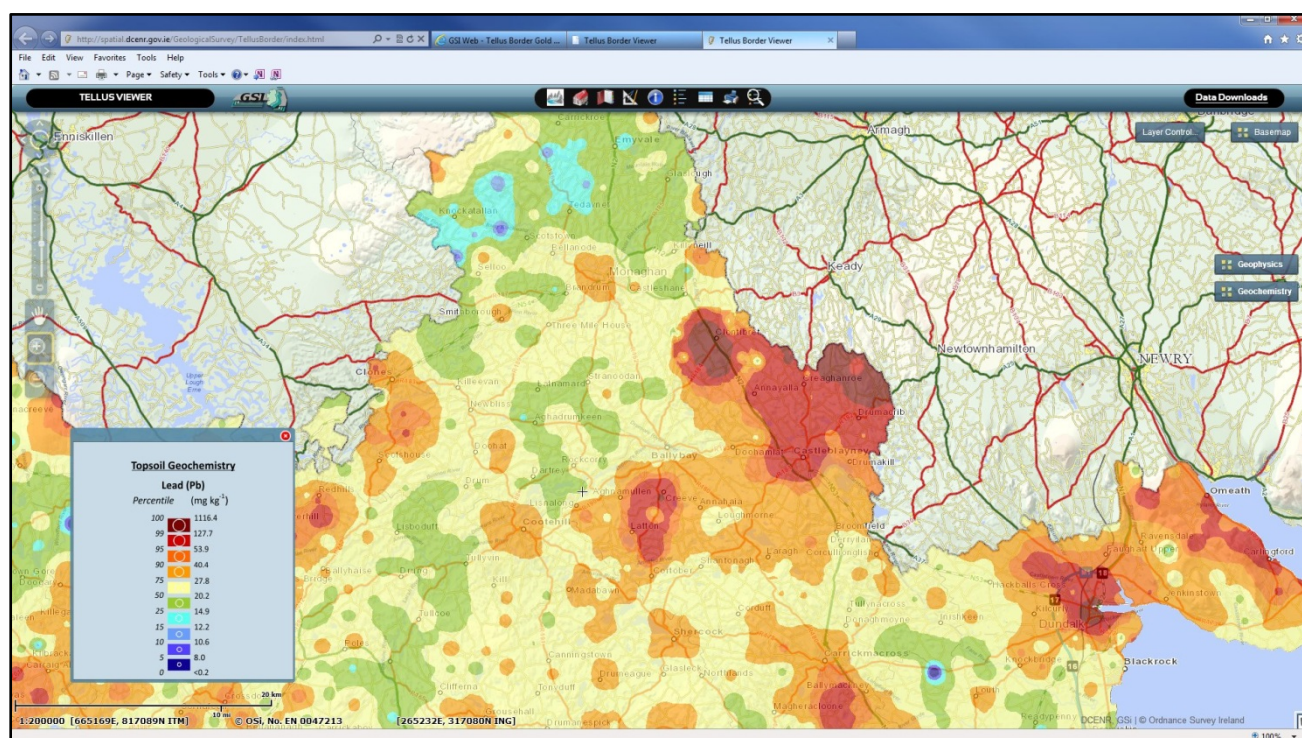
Subsoils Mapping

Since a Groundwater Protection Scheme has been completed (2001) for County Monaghan by GSI, a modern map of the subsoil types and depths across Monaghan 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. Furthermore, detailed compilation of glacial geology datasets, including a revision to be published by GSI in late-2013, will provide more data from late 2013 onwards.

Digital mapping of many different datasets is now available via an easy to use public viewer on 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 Monaghan) 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 Monaghan, as seen on the TELLUS map viewer at www.gsi.ie. See the high concentrations in many of the areas in east Monaghan where lead was mined historically.

Shortlist of Key Geological References

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

DALY, D., DREW, D.P., DEAKIN, J., PARKES, M. and WRIGHT, J. 2001. *The Karst of Ireland; Limestone Landscapes, Caves and Groundwater Drainage Systems*. Karst Working Group Dublin, 37pp.

GERAGHTY, M., CLARINGBOLD, K., HUDSON, M., FARRELLY, I., JORDAN, C.J. and MEEHAN, R.T. 1997. *Geology of Monaghan-Carlingford. A geological description to accompany the Bedrock Geology 1:100,000 Map Series, Sheets 8 and 9, Monaghan-Carlingford*. Geological Survey of Ireland, Dublin, 60pp.

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

MacDERMOT, C.V., LONG, C.B. and HARNEY, S.J. 1996. *Geology of Sligo-Leitrim*. Geological Survey of Ireland Bedrock Geology Sheet 7.

MITCHELL, G.F. and RYAN, M., 1997. *Reading the Irish Landscape*. Town House Press, 397 pp.

MCCONNELL, B., PHILCOX, M.E., GERAGHTY, M., MORRIS, J., COX, W., WRIGHT, G.R. and MEEHAN, R.T., 2001. *Geology of Meath. A geological description to accompany the Bedrock Geology 1:100,000 Map Series, Sheet 13, Meath*. Geological Survey of Ireland, Dublin, 78pp

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 Monaghan that could be traced.

Caving References

The references in Appendix 3 relate significantly to caves and caving within the Monaghan area. They may only be brief reports or newsletter items. They are generally available within the Speleological Union of Ireland Library which is housed in the Geological Survey of Ireland and is managed by Matthew Parkes.

Mining heritage references

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

Quaternary References

The references in Appendix 4 all cover the Quaternary, or Ice Age, geology of Monaghan. They are split into references specifically covering sites or features in Monaghan, and a section of national or regional papers which have some data from or on Monaghan 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. Shirley Clerkin, the Heritage Officer of Monaghan 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

<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

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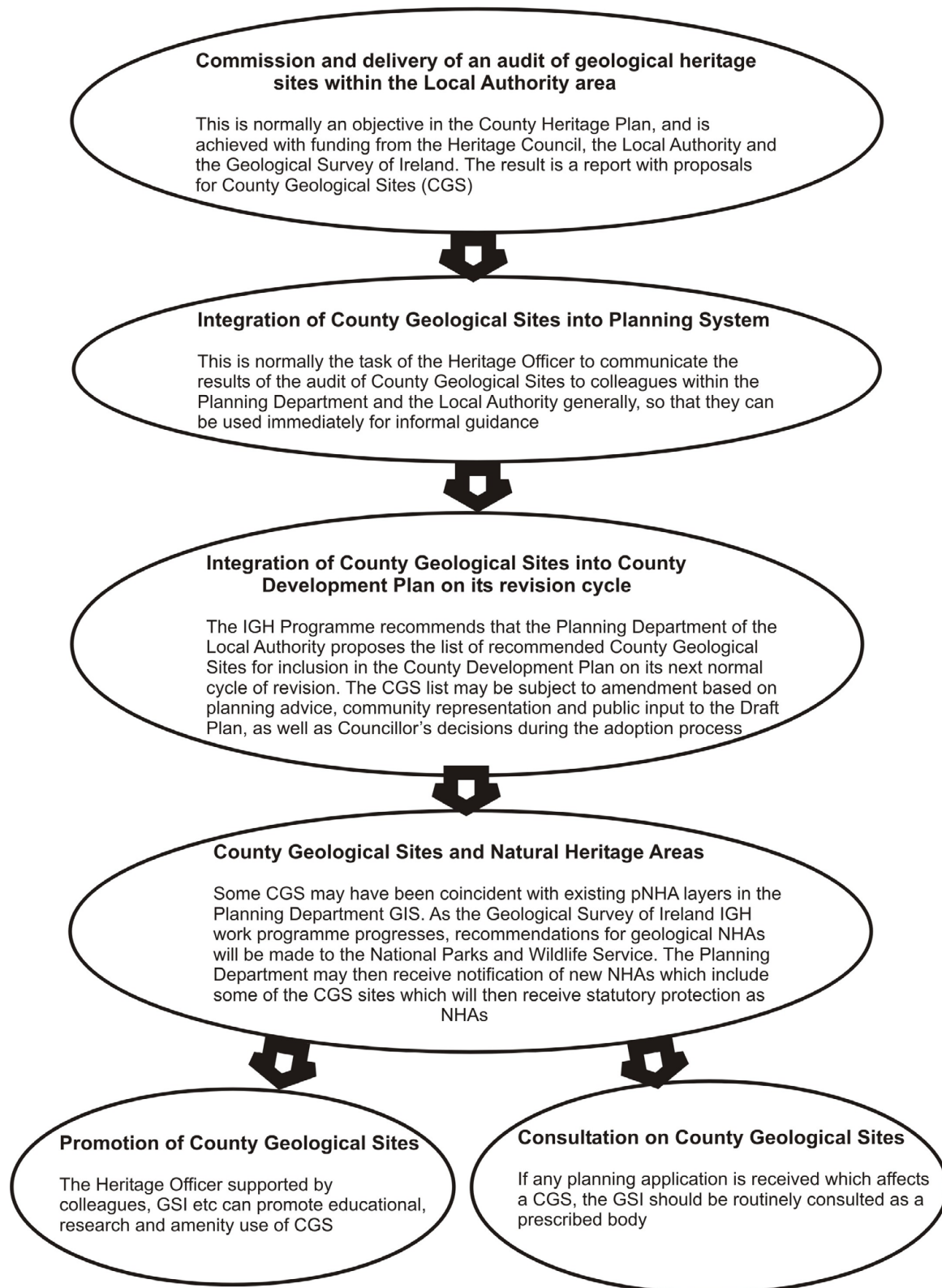
Appendix 1 – Geological heritage audits and the planning process

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: the Planning and Development Act 2000 [e.g. Sections 212 (1)f; Part IV, 6; First Schedule Condition 21], the Planning and Development Regulations 2001, the Wildlife (Amendment) Act 2000 (enabling Natural Heritage Areas) and the Heritage Act 1995. The Planning and Development Act 2000 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 GSI, over the course of numerous county audits since 2004.

County Geological Sites - a step by step guide



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Appendix 5 – 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 Monaghan's geology and especially the karst and caves around Carrickmacross. It was known, for example, that caves in Monaghan had not been adequately considered in the preparation of the IGH Master site list. 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.

Corleck Caves

A 20 m long cave is found in the 125 m-long zone between a small river sink and its rising. The river sinks again after 100 m but nothing observed at the site was of sufficient importance to consider it a County Geological Site.



The Corleck river sink.



Rubbish accumulated in the sink.

Lisgall Caves

The roadside sink whilst visible on one side is screened by walls on the other so the 30 m of low, tight crawling cave is not apparent. Cavers have been informed they are not welcome. The double lime kiln on the opposite side of the road sink provides industrial heritage interest but is well screened on private land and is not visitable.



The river flows from left to right and sinks at the stone revetment, under the road.

Carrickmacross area - Crescentic drumlins

A number of grid references were given in the IGH Master Site for crescentic drumlins around Carrickmacross: only one of these (at Leeg, which has been listed and detailed in the main report as a County Geological Site) is actually a discrete drumlin ridge.

All the other features listed are part of larger ribbed moraine features, hence cannot be defined as discrete drumlins.

Tobermannan Bridge

This site was originally recorded as an ASI of local interest for an echinoderm fauna (fossil blastoids of the genus *Orbitremites*) in a bed of limestone below the bridge. Some isolated thecae were also found weathered out in the soil above the limestone. Examination of the site, including both upstream and downstream of the bridge, failed to find any prominent bed of limestone, as described; indeed, very little rock is visible at all. There may have been some bank strengthening and reconstruction in the intervening decades, which has removed or damaged the fossil interest. It is therefore not possible to recommend inclusion of this site as a County Geological Site.



Bank revetment at Tobermannan Bridge may have obscured or removed the fossiliferous bed of former interest.

Limestone Quarry at Annahaia

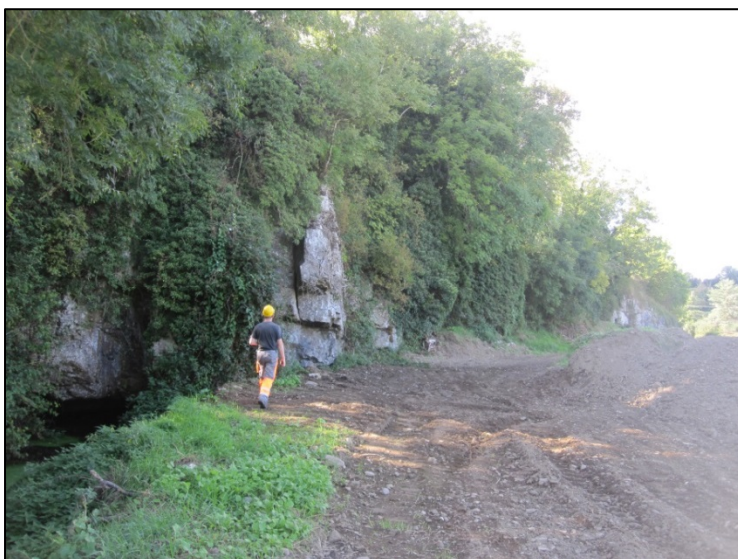
A disused limestone quarry made noticeable because of a prominent roadside lime kiln was examined during field survey work for the audit. Due to subsequent landscaping of the quarry area, there is relatively little rock exposure left and insufficient interest to merit consideration as a County Geological Site.



The lime kiln is central in a quarried area but the site is lacking in rock faces of any great extent or importance.

Creevy Quarry sinks and risings

In the riverside quarry at Creevy there are some small sinks and risings of a river that contributes to the main river sinking into Creevy Cave, the water probably coming from Aphuca Cave. The old quarry intersected sections of cave passage and water rises in two main sites at the foot of the quarry face. In themselves they do not merit County Geological Site recognition, and the site is too removed from the Creevy Cave sink to be considered as a part of that site.



One rising is the left of Robert Meehan, the other at the far end of the quarry face.

Lisdrumgormly mine

The Lisdrumgormly deposit was mined for lead as early as the 1830s and was the subject of further exploration during the mid-1950s when the original shaft was reopened to a depth of 21m. The underground workings comprise narrow, 1.5m-wide stopes above a northwest-southeast-trending level. Assays of over 22% Pb were recorded by the Mining Corporation of Ireland in 1956. Access to the underground mine was by a shaft apparently almost 50m deep. The plug of this shaft collapsed in 2012 revealing a cylindrical shaft, collared in stone, dipping steeply east. The shaft was subsequently backfilled and fenced. A largely overgrown waste dump and a disused outbuilding are the most obvious traces of mining on the site. A depression approximately 20 x 10m in size adjacent to the waste heap may be a consequence of subsidence above the underground workings. Mineralized material in the waste dumps consists of greywacke sandstone cut by thin dolomite veins containing galena as well as brecciated sandstone with quartz and carbonate, with or without galena or barite. The only tangible mine feature on the site is the waste dump. Boulders within this dump provide evidence for the mineralization but they are not particularly impressive examples and insufficient to warrant CGS status for the site.

A detailed geological map of County Monaghan



Appendix 7 - Geoschol leaflet on the geology of County Monaghan



MONAGHAN

AREA OF COUNTY: 1,294 square kilometres or 499 square miles

COUNTY TOWN: Monaghan

OTHER TOWNS: Carrickmacross, Castleblayney, Clones

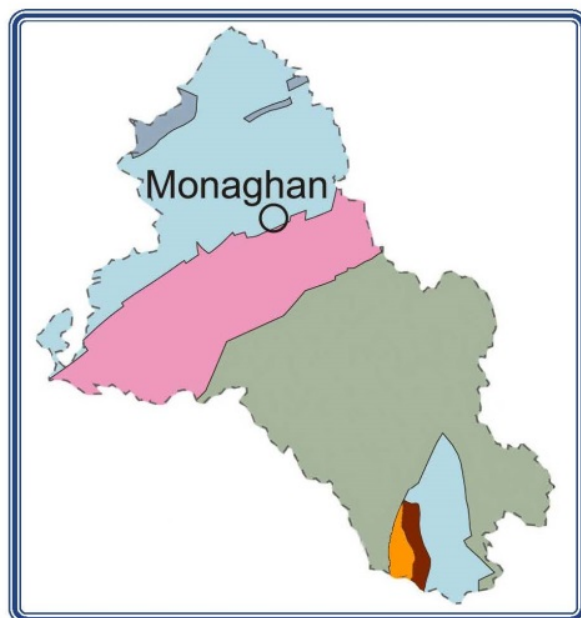
GEOLOGY HIGHLIGHTS: Gypsum deposits

AGE OF ROCKS: Ordovician, Silurian, Carboniferous, Permian, Triassic, Paleogene



Milltown Lake, Oram, near Castleblayney

This lake is nestling among rounded drumlins which are composed of sediments deposited as the ice of the Ice Age melted away.



Geological Map of County Monaghan

Pink: Ordovician sediments; **Green:** Ordovician & Silurian; **Dark blue:** Lower Carboniferous sandstones; **Light blue:** Lower Carboniferous limestone; **Brown:** Upper Carboniferous shales; **Orange:** Triassic sandstones.

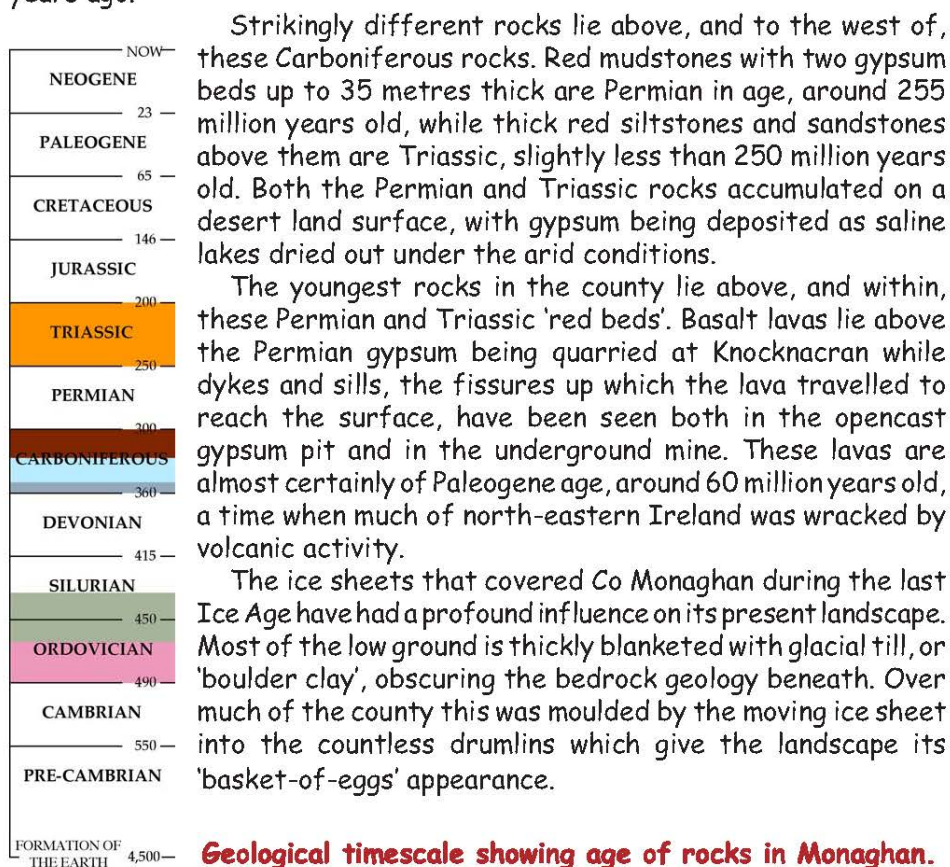
Geological history

With the exception of the southern slopes of Slieve Beagh, in the extreme north-west of the county, the landscape of Monaghan is low and gently undulating. The oldest rocks form a strip from north-east to south-west across the centre of the county. These Ordovician rocks, around 460 to 445 million years old, consist mostly of mudstone and muddy sandstones, or 'greywackes', but include some submarine lavas. They accumulated on the floor of an ocean at a depth of more than 4000 metres. Similar dark mudstones and greywackes of Silurian age, around 445 to 440 million years old, again with some minor submarine volcanics, form a much broader band across much of the southern half of the county.

The northern third of the county is underlain by Carboniferous rocks, from around 360 to 330 million years old. They are very poorly exposed but boreholes show that the earlier rocks are pebble beds and sandstones,

overlain by limestones and then by thick mudstones and sandstones on the south slopes of Slieve Beagh. The pebble beds at the base were deposited in broad shallow rivers which were gradually submerged, as sea level rose, by lagoons and then by shallow tropical seas represented by the limestones. The younger mudstones and sandstones above them were deposited by river deltas encroaching into the sea as sea level was falling again.

Carboniferous and younger rocks, surrounded by much older Silurian rocks, are found in the extreme south-east of the county where they have subsided along a major tectonic fault. Grey Carboniferous limestone, deposited on a shallow sea floor around 330 million years old, are overlain by younger Carboniferous sandstones and mudstones, with a few thin coal seams, deposited in an Equatorial swamp or delta environment around 320 million years ago.



Monaghan fossils

The bedrock of Co. Monaghan is so extensively covered by glacial deposits that there are few opportunities to find fossils. Almost the only fossils found in the Ordovician and Silurian rocks are the pencil-marking like fossils of graptolites. The Carboniferous limestones contain typical fossils, such as corals and brachiopods, which may be found where these rocks are exposed.

Mining & Building Stones

Two quarries in the Silurian greywackes, one in the Carboniferous limestone and one in glacial sand and gravel extract material for use as road chippings and aggregate for the construction industry. There is a working brick pit at Losset and others, now disused, near Carrickmacross and Castleblayney.

Knocknacran Mine, a few kilometres south of Carrickmacross, has been worked both underground and opencast. It is Ireland's most important producer of gypsum and has long been a major source of plaster products for the construction industry.



Red Permian mudstone and gypsum, and grey rotted basalt, at the Knocknacran opencast mine.

Map adapted with permission from Geological Survey of Ireland 1:1,000,000 map 2003
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Mike Simms 4.



www.geoschol.com

Text by Mike Simms

Section 2 - Site Reports

Site reports – general points

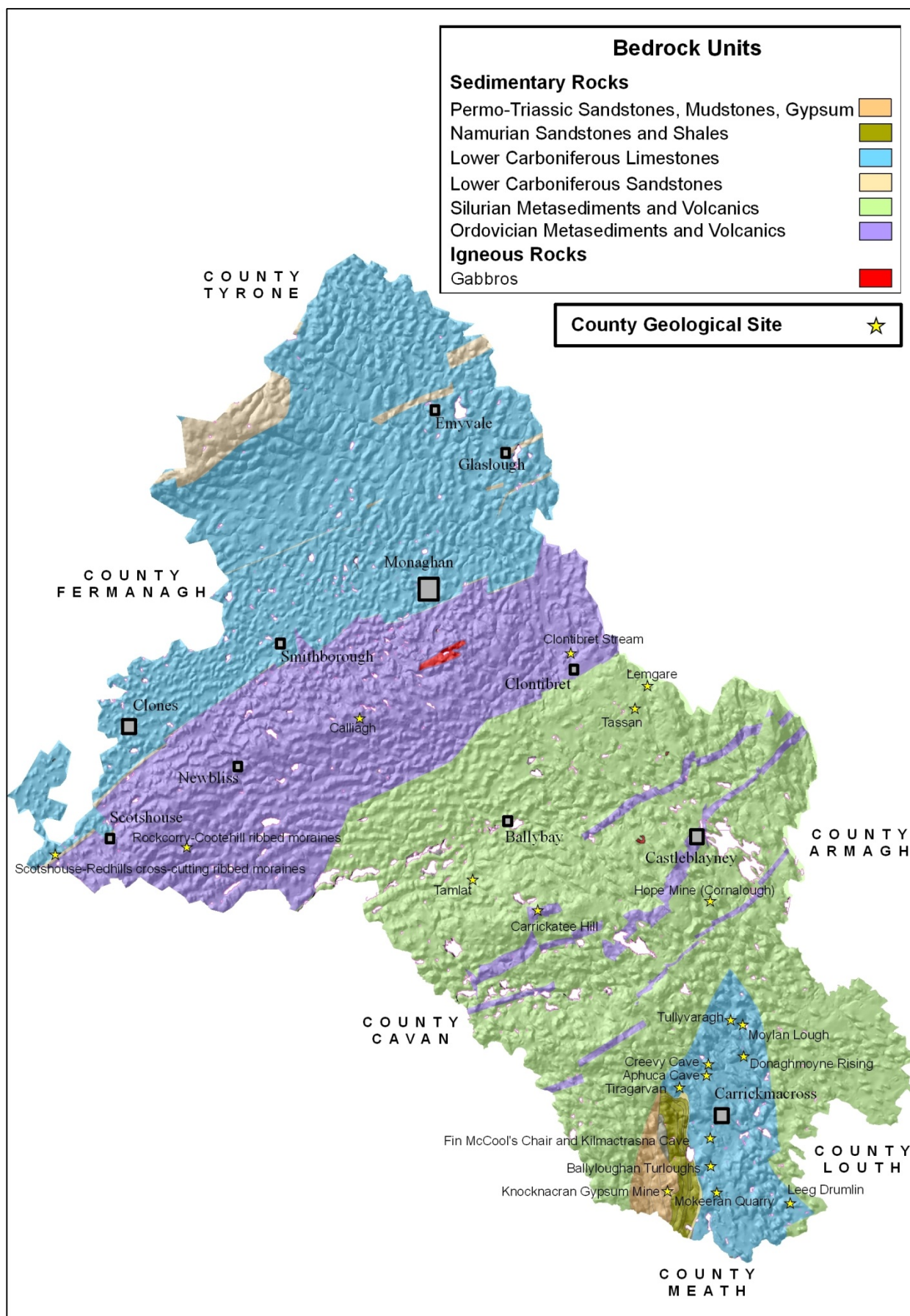
The following site reports are brief non-technical summaries of the proposed County Geological Sites for County Monaghan. These have been specially prepared for this Report in order to make the information accessible to planners and others without geological training. For most sites more detailed reports 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. **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 recommended or which will be recommended 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 these wider areas 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 finalises recommendations with 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 Monaghan with site locations indicated.