



# The Geological Heritage of County Tipperary

### An audit of County Geological Sites in County Tipperary 2019

Vincent Gallagher, Robert Meehan, Matthew Parkes, Ronan Hennessy and Siobhán Power



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2019

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# **Contents** Section 1 – Main Report

| Execut   | tive Summary  | 7  |  |  |  |  |  |  |
|--|---|----|--|--|--|--|--|--|
| 1.   | County Tipperary in the context of Irish Geological Heritage              | 8  |  |  |  |  |  |  |
|  | 1.1 Tipperary County Geological Sites                                     | 10 |  |  |  |  |  |  |
|  | 1.2 Combined, Renamed and Rejected sites                                  | 12 |  |  |  |  |  |  |
| 2.   | Tipperary Council policies regarding geological heritage    3             |    |  |  |  |  |  |  |
| 3.   | Geological conservation issues and site management                        | 32 |  |  |  |  |  |  |
|  | 3.1 Geological heritage theme – The Southern Irish End Moraine            | 35 |  |  |  |  |  |  |
|  | 3.2 Geological heritage theme – Sub-glacial bedforms in County Tipperary. | 36 |  |  |  |  |  |  |
|  | 3.3 Geological heritage theme – Karst in Ireland, and in Tipperary        | 37 |  |  |  |  |  |  |
|  | 3.4 Geological heritage theme – The Littletonian                          | 37 |  |  |  |  |  |  |
| 4.   | Summary and Recommendations   | 39 |  |  |  |  |  |  |
|  | 4.1 Proposals and ideas for promotion of geological heritage in Tipperary | 39 |  |  |  |  |  |  |
|  | 4.2 Specific ideas for projects   | 42 |  |  |  |  |  |  |
| 5.   | A summary of the geology of County Tipperary                              |    |  |  |  |  |  |  |
| 6.   | Acknowledgements  | 50 |  |  |  |  |  |  |
| Appen  | ndix 1 Geological heritage audits and the planning process                | 51 |  |  |  |  |  |  |
| Appen  | ndix 2 Bibliography – Geology of County Tipperary                         | 53 |  |  |  |  |  |  |
| Appendix 3 Bibliography – Caves and karst of County Tipperary    |   |    |  |  |  |  |  |  |
| Appendix 4 Bibliography – County Tipperary Quaternary References |   |    |  |  |  |  |  |  |
| Appen  | ndix 5 Geological heritage versus geological hazards                      | 69 |  |  |  |  |  |  |
| Appen  | ndix 6 Data sources on the geology of County Tipperary                    | 71 |  |  |  |  |  |  |
| Appen  | ndix 7 Further sources of information and contacts                        | 76 |  |  |  |  |  |  |
| Appendix 8 Geoschol leaflet on the geology of County Tipperary   |   |    |  |  |  |  |  |  |
| Appendix 9 Glossary of geological terms 81                       |   |    |  |  |  |  |  |  |
| Sectio   | n 2 – Site Reports  |    |  |  |  |  |  |  |
| Site reports – general points                                    |   |    |  |  |  |  |  |  |
| Site re  | ports – location map  | 87 |  |  |  |  |  |  |
| IGH 1  | Karst   |    |  |  |  |  |  |  |
| Site N   | ame   |    |  |  |  |  |  |  |
| Annagh Mushroom Rock   |   |    |  |  |  |  |  |  |
| Ballyduff-Clonmona Mushroom Rocks                                |   |    |  |  |  |  |  |  |
| Dangan Wusnroom Rock   |   |    |  |  |  |  |  |  |
| Witcheistown Caves   |   |    |  |  |  |  |  |  |
| Newchapel Turlough [see IGH16]                                   |   |    |  |  |  |  |  |  |

#### IGH 1 Karst (continued)

Polldonragh and the Bulls Hole of Rocks [see IGH16] Roaring Wells Tincurry Sink [see IGH16] Toberadora [see IGH16]

#### **IGH 2 Precambrian to Devonian Palaeontology**

Site Name

Borrisnoe and Cloncannon [see IGH4] Reafadda Quarry [see IGH4]

IGH 3 Carboniferous to Pliocene Palaeontology Site name Ballymacadam [see IGH12] Ballyoughter Bridge

#### **IGH 4 Cambrian-Silurian**

Site name Birdhill M7 Road Cut Borrisnoe and Cloncannon [see IGH2] Carrigatogher M7 Road Cut Fantane Quarry Latteragh Quarry Reafadda Quarry [see IGH2]

#### **IGH 5 Precambrian**

Site name Not represented in County Tipperary

#### IGH 6 Mineralogy

Site Name Ballygown [see IGH15] Garryard [see IGH15] Gortdrum [see IGH15]

#### IGH 7 Quaternary

Site Name Ardcrony Esker Ardfinnan Arragh More Bog [see IGH16] Bansha and Castle Mary Moraine and Outwash Bay Lough Corrie Fiagh Bog [see IGH16] Galtee Mountains Glen of Aherlow

#### **IGH 7 Quaternary (continued)**

Kilcarren-Firville Bog [see IGH16] Killough Hill [see IGH8] Kilmastulla Meltwater Channels Lissvarrinane Meltwater Channels Little Brosna Callows [see IGH14] Littleton Bog [see IGH14 and IGH16] Monaraha Esker Nore Valley Bogs [see IGH16] Owenbeg Moraines Rear Cross Moraines River Shannon Callows [see IGH14] Scohaboy Bog [see IGH16]

#### IGH 8 Lower Carboniferous Site Name

Ballyrichard Quarry Ballytarsna M8 Road Cut Cloghleigh Quarry Horeabbey [see IGH9] Kilfeacle Quarry Killough Hill [see IGH7] Knockordan Hill Laffansbridge Quarry Rock of Cashel Touknockane M7 Road Cut

#### IGH 9 Upper Carboniferous and Permian Site Name

Bregaun Hill Quarry Horeabbey [see IGH8]

#### **IGH 10 Devonian**

Site Name Clare Glens [see IGH14] Devilsbit [see IGH12] Seefin

IGH 11 Igneous intrusions Site Name Not represented in County Tipperary

#### IGH 12 Mesozoic and Cenozoic Site Name Ballymacadam [see IGH3] Devilsbit [see IGH10]

IGH 13 Coastal Geomorphology Site Name Not represented in County Tipperary

#### IGH 14 Fluvial and Lacustrine Geomorphology

Site Name

Cabragh Wetlands [see IGH16] Clare Glens [see IGH10] Clodiagh River Meanders Little Brosna Callows [see IGH7] Littleton Bog [see IGH7 and IGH16] River Shannon Callows River Shannon Callows [see IGH14]

#### IGH 15 Economic Geology

Site Name Gortdrum [see IGH6] Hollyford Mines Lisheen Mine Portroe Silvermines Ballygown [see IGH6] Garryard [see IGH6] Magcobar Shallee Slieve Ardagh Ballingarry-Copper Ballynunty-Mardyke Coalbrook Commons Earlshill Gorteen Thurles Cathedral

#### IGH 16 Hydrogeology Site Name

Arragh More Bog [see IGH7] Cabragh Wetlands [see IGH14] Fiagh Bog [see IGH7] Kilcarren-Firville Bog [see IGH7] Littleton Bog [see IGH7 and IGH14] Marlfield Newchapel Turlough [see IGH1] Nore Valley Bogs [see IGH7] Polldonragh and the Bulls Hole of Rocks [see IGH1] Scohaboy Bog [see IGH7] Tincurry Sink [see IGH1] Toberadora [see IGH1] Tobernaloo

#### **Executive Summary**

County Tipperary is not widely known for its geological heritage, although for many people the landscape with a number of striking mountain ranges is widely appreciated. Although bedrock is not generally well exposed, Tipperary still has an extensive and diverse range of geological heritage sites. The County Council's support for this audit is critical in raising the profile of geological heritage in County Tipperary and for maximising its potential for foreign and domestic tourism and for natives alike.

This report documents what are currently understood by the Irish Geological Heritage Programme (IGH) of Geological Survey Ireland to be the most important geological sites within County Tipperary. It proposes them as County Geological Sites (CGS), for inclusion within the County Development Plan (CDP). The audit provides a reliable study of sites to replace a provisional Geological Survey Ireland listing based on desk study which was adopted in the current 2014-2020 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. Some of the sites described in this report are considered to be of national importance as a best representative example of a particular geological formation or feature. They will be provisionally notified to the National Parks and Wildlife Service (NPWS) by Geological Survey Ireland for designation as a Natural Heritage Area (NHA) once due survey and consultation with landowners is complete. In parts of the county, many of the sites fall within existing pNHAs and SACs where the ecological interest is actually founded upon the underlying geodiversity.

The commission of this audit and adoption of the sites within the CDP ensure that County Tipperary follows a now established and effective methodology for ensuring that geological heritage is not overlooked in the general absence of allocated resources for progress with geological NHAs at national level. It brings County Tipperary to 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 officers of Tipperary County Council. It should also be made available via the Council website for the people of County Tipperary. A chapter of the report includes recommendations on how to best present and promote the geological heritage of County Tipperary to the people of the county. It will also inform the work of the IGH Programme and be made available through the Geological Survey Ireland website.

The preliminary sections, summary geological history and accompanying map, timescale and stratigraphical column in particular 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, and as funding permits. The contents also provide the essential ingredients for a public-oriented book or other publications on the geological heritage of County Tipperary, if the funding can be found to produce them.

#### 1. County Tipperary in the context of Irish Geological Heritage

This report brings County Tipperary to the forefront of geological heritage within Ireland, as the majority of the counties have now commissioned such an audit within the scope of the countybased Heritage Plan, and Tipperary has a very interesting suite of sites which have not previously been audited. By providing reliable data in a very cost-effective manner, it is planned that the remaining local authorities, including those without an incumbent Heritage Officer, will follow what is now a tried and trusted methodology, to complete a national coverage of County Geological Sites.

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), audits such as this one represent a significant level of progress in defining and safeguarding Ireland's geological heritage. In essence, County Geological Site audits are the only effective geological conservation at present, but only with advisory capacity (within the context of County Development Plans) and no real statutory protection where it is required, although the statutory County Development Plan provides capacity to preserve sites where necessary.

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). Geological Survey Ireland 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 Geological Survey Ireland complements other existing nature conservation efforts, 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 on a national scale by the introduction of Natural Heritage Areas (NHA) as the national nature conservation method (so far only a suite of bog sites have been designated). 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 end of the Areas of Scientific Interest scheme, as 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

The philosophy and rationale for NHA designation of geological sites has been well documented in several publications (Parkes and Morris 2001; Parkes 2008; Gatley and Parkes 2016, 2018), and is not reiterated here since County Geological Sites are the present concern. Future possible designation of geological NHAs would be by Geological Survey Ireland'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 County Tipperary 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, all candidate geological NHAs are of national importance. Many other sites may be of more local importance or of particular value as educational sites or as a public amenity. All of these various important sites are proposed for County Geological Site (CGS) listing in the County Development Plan.

Currently, in 2019, a Master List of candidate CGS and NHA sites is being used in Geological Survey Ireland, originally compiled 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. In County Tipperary, some karst sites like Roaring Wells and Mitchelstown Cave were so far considered to be of national importance and had been put forward as a Natural Heritage Area (NHA) for the IGH1 Karst Theme. For the IGH2 Precambrian to Devonian Palaeontology Theme, Borrisnoe and Cloncannon and Reafadda Quarry were also proposed to NPWS for NHA designation. Therefore, inclusion of <u>all</u> sites as County Geological Sites (CGS) in County Tipperary'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 Geological Survey Ireland.

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 future 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 CGS 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.

## **1.1 Tipperary County Geological Sites**

| Site Name                 | Designation                    | IGH     | IGH       | IGH   | GIS     |
|---------------------------|--------------------------------|---------|-----------|-------|---------|
|                           |                                | Primary | Secondary | Third | Code    |
| Annagh Mushroom Rock      | County Geological Site         | IGH1    |           |       | TY001   |
| Ardcrony Esker            | County Geological Site         | IGH7    |           |       | TY002   |
| Ardfinnan                 | County Geological Site         | IGH7    |           |       | TY003   |
| Arragh More Bog           | County Geological Site; may be | IGH7    | IGH16     |       | TY004   |
|                           | recommended for Geological NHA |         |           |       |         |
| Balllingarry-Copper       | County Geological Site; may be | IGH15   |           |       | TY005   |
|                           | recommended for Geological NHA |         |           |       |         |
| Ballyduff-Clonmona        | County Geological Site         | IGH1    |           |       | TY006   |
| Mushroom Rocks            |                                |         |           |       |         |
| Ballygown                 | County Geological Site         | IGH15   | IGH6      |       | TY007   |
| Ballymacadam              | County Geological Site;        | IGH3    | IGH12     |       | TY008   |
|                           | recommended for Geological NHA |         |           |       | -       |
| Ballynunty-Mardyke        | County Geological Site         | IGH15   |           |       | TY009   |
| Ballyoughter Bridge       | County Geological Site         | IGH3    |           |       | TY010   |
| Ballyrichard Quarry       | County Geological Site; may be | IGH8    |           |       | TY011   |
|                           | recommended for Geological NHA |         |           |       |         |
| Ballytarsna M8 Road Cut   | County Geological Site         | IGH8    |           |       | TY012   |
| Bansha and Castle Mary    | County Geological Site         | IGH7    |           |       | TY013   |
| Moraine and Outwash       |                                |         |           |       | T)(04.4 |
| Bay Lough Corrie          | County Geological Site         |         |           |       | TY014   |
| Birdhill M/ Road Cut      |                                | IGH4    |           |       | TY015   |
| Bornshoe and Cioncannon   | county Geological Site;        | IGHZ    | IGH4      |       | 11010   |
| Brogoup Hill Quarpy       |                                |         |           |       | TV017   |
| Cabragh Wetlands          |                                |         | IGH16     |       | TV012   |
| Caprigatogher M7 Road Cut |                                |         | IGHIO     |       | TV010   |
| Clare Glens               |                                |         | IGH14     |       | TY020   |
| Clodiagh River Meanders   | County Geological Site         | IGH14   |           |       | TY020   |
| Cloghleigh Quarry         | County Geological Site         | IGH8    |           |       | TY022   |
| Coalbrook                 | County Geological Site         | IGH15   |           |       | TY023   |
| Commons                   | County Geological Site         | IGH15   |           |       | TY024   |
| Dangan Mushroom Rock      | County Geological Site         | IGH1    |           |       | TY025   |
| Devilsbit                 | County Geological Site;        | IGH10   | IGH12     |       | TY026   |
|                           | recommended for Geological NHA |         |           |       |         |
| Earlshill                 | County Geological Site         | IGH15   |           |       | TY027   |
| Fantane Quarry            | County Geological Site;        | IGH4    |           |       | TY028   |
|                           | recommended for Geological NHA |         |           |       |         |
| Fiagh Bog                 | County Geological Site         | IGH7    | IGH16     |       | TY029   |
| Galtee Mountains          | County Geological Site;        | IGH7    |           |       | TY030   |
|                           | recommended for Geological NHA |         |           |       |         |
| Garryard                  | County Geological Site         | IGH15   | IGH6      |       | TY031   |
| Glen of Aherlow           | County Geological Site;        | IGH7    |           |       | TY032   |
|                           | recommended for Geological NHA |         |           |       |         |
| Gortdrum                  | County Geological Site         | IGH15   | IGH6      |       | TY033   |
| Gorteen                   | County Geological Site         | IGH15   |           |       | TY034   |
| Hollyford Mines           | County Geological Site         | IGH15   |           |       | TY035   |
| Horeabbey                 | County Geological Site         | IGH8    | IGH9      |       | TY036   |
| Kilcarren-Firville Bog    | County Geological Site;        | IGH7    | IGH16     |       | TY037   |
|                           | recommended for Geological NHA |         |           |       |         |
| Kilfeacle Quarry          | County Geological Site         | IGH8    |           |       | TY038   |

| Site Name                 | Designation                    | IGH     | IGH       | IGH   | GIS   |
|---------------------------|--------------------------------|---------|-----------|-------|-------|
|                           |                                | Primary | Secondary | Third | Code  |
| Killough Hill             | County Geological Site         | IGH8    | IGH7      |       | TY039 |
| Kilmastulla Meltwater     | County Geological Site         | IGH7    |           |       | TY040 |
| Channels                  |                                |         |           |       |       |
| Knockordan Hill           | County Geological Site         | IGH8    |           |       | TY041 |
| Laffansbridge Quarry      | County Geological Site         | IGH8    |           |       | TY042 |
| Latteragh Quarry          | County Geological Site         | IGH4    |           |       | TY043 |
| Lisheen Mine              | County Geological Site         | IGH15   |           |       | TY044 |
| Lissvarrinane Meltwater   | County Geological Site         | IGH7    |           |       | TY045 |
| Channels                  |                                |         |           |       |       |
| Little Brosna Callows     | County Geological Site         | IGH14   | IGH7      |       | TY046 |
| Littleton Bog             | County Geological Site; may be | IGH7    | IGH14     | IGH16 | TY047 |
|                           | recommended for Geological NHA |         |           |       |       |
| Magcobar                  | County Geological Site         | IGH15   |           |       | TY048 |
| Marlfield                 | County Geological Site         | IGH16   |           |       | TY049 |
| Mitchelstown Caves        | County Geological Site;        | IGH1    |           |       | TY050 |
|                           | recommended for Geological NHA |         |           |       |       |
| Monaraha Esker            | County Geological Site         | IGH7    |           |       | TY051 |
| Newchapel Turlough        | County Geological Site         | IGH1    | IGH16     |       | TY052 |
| Nore Valley Bogs          | County Geological Site         | IGH7    | IGH16     |       | TY053 |
| Owenbeg Moraines          | County Geological Site         | IGH7    |           |       | TY054 |
| Polldonragh and the Bulls | County Geological Site         | IGH1    | IGH16     |       | TY055 |
| Hole of Rocks             |                                |         |           |       |       |
| Portroe                   | County Geological Site         | IGH15   |           |       | TY056 |
| Reafadda Quarry           | County Geological Site;        | IGH2    | IGH4      |       | TY057 |
|                           | recommended for Geological NHA |         |           |       |       |
| Rear Cross Moraines       | County Geological Site         | IGH7    |           |       | TY058 |
| River Shannon Callows     | County Geological Site;        | IGH14   | IGH7      |       | TY059 |
|                           | recommended for Geological NHA |         |           |       |       |
| Roaring Wells             | County Geological Site;        | IGH1    |           |       | TY060 |
|                           | recommended for Geological NHA |         |           |       |       |
| Rock of Cashel            | County Geological Site         | IGH8    |           |       | TY061 |
| Scohaboy Bog              | County Geological Site         | IGH7    | IGH16     |       | TY062 |
| Seefin                    | County Geological Site         | IGH10   |           |       | TY063 |
| Shallee                   | County Geological Site         | IGH15   |           |       | TY064 |
| Thurles Cathedral         | County Geological Site         | IGH15   |           |       | TY065 |
| Tincurry Sink             | County Geological Site;        | IGH1    | IGH16     |       | TY066 |
|                           | recommended for Geological NHA |         |           |       |       |
| Toberadora                | County Geological Site         | IGH1    | IGH16     |       | TY067 |
| Tobernaloo                | County Geological Site         | IGH16   |           |       | TY068 |
| Tourknockane M7 Road Cut  | County Geological Site         | IGH8    |           |       | TY069 |

#### 1.2 Combined, Renamed and Rejected sites

A range of additional sites were assessed in the audit, based on the authors' expert knowledge of Tipperary's geology. It was known, for example, that many of the karstic areas of the county had not been adequately considered in the preparation of the IGH Master Site list. Similarly, some quarry localities had not been adequately considered in the IGH Master Site list, which was focused on nationally important sites as candidates for Natural Heritage Area (NHA) status. It should also be noted here that the original creation of the Master Site List was very much a preliminary desk-based study, using expert panels for the 16 different geological themes. Inevitably some sites got overlooked, but these have now been rectified as far as possible. Some of the listed sites were included under different geological interests, sometimes overlapping or equivalent areas, so the actual site areas and interests have been combined and rationalised in this audit process. In addition, some of the new sites had been identified in the course of Geological Survey Ireland research work in the period since the Master Site List was created and this audit was undertaken. Other sites were also visited on spec during fieldwork.

A range of sites were originally indicated in the IGH Master Site list based on expert panels, and have previously been included in the Tipperary CDPs; some anomalies survived the development process (in other counties as well) to become included in the County Development Plan. Some of these sites have been assessed as unsuitable for County Geological Site status in this audit, and their rejection has been approved by Geological Survey Ireland after reviewing the case for each. The combined, renamed and rejected sites are listed below with brief notes as to why they were assessed as unsuitable for inclusion.

#### **Mitchelstown Caves**

This is now one site that combines the Mitchelstown Show Cave, the Old Desmond Cave and Pollskeheenarinky. The Old Desmond Cave was a very early show cave which was overtaken as a visitor attraction by Mitchelstown Cave, which was discovered in 1833. Underground they are separated by only around 50m. Pollskeheenarinky is a few hundred metres further away but all three are significant caves formed along the same belt of steeply dipping limestone. Although originally listed as separate sites in the Master Site List it was intended that they should be defined as one linked site when they were to be designated as a geological NHA. As a single County Geological Site this intention is achieved. A further small cave, Lios Carrigeen was under consideration for inclusion within the combined site in around 2005, however this has not been included as the cave survey and description indicate that it is very small and not as significant as the others.

#### **Ballagh Caves**

A number of small linear caves up to 45m in length previously existed in disused quarry at Ballagh in mid Tipperary, southwest of Thurles and northwest of Cashel. These were described by Parkes and Critchley (1997). They would have been a good candidate for CGS status as examples of how karstification has affected the Ballysteen Limestone Formation in this region but unfortunately a 'Celtic Tiger' development has now destroyed them. The lower parts of the quarry were backfilled and from local reports and what is visible, a ghost estate now occupies the quarry, with cave entrances buried in fill or cover for a redundant sewage processing tank system.



The Ballagh caves site.

#### Lackamore

The Anglesey Road runs east-west through Slieve Felim and originally went past Lackamore copper mine. This was worked in the early 1800s and was a significant mine. A deep, steep walled pit with many mine adits off it survived until perhaps January 2008 when it is reported that the pit was backfilled by the landowner, with the spoil which surrounded the pit. The drastic landscaping has remodelled the site and removed any mining heritage interest in the site, although what was probably the Mine Captain's House is extant and occupied as a dwelling. A single bank of mine spoil or overburden is visible, which was left as it has a boundary fence upon it.



The old Lackamore copper mine site.

#### Knockgraffon

The former extraction of ball clays or pipe clays from Knockgraffon is reported in several papers with very little detail, but investigation of maps, prospecting licence reports and technical literature sources suggests that Knockgraffon sources were never that significant nor exploited in any volume. The clays are found as residual deposits within karstic depressions or dolines. Knockgraffon Hill is composed of cherty limestones and two very small limestone quarries are found within a few hundred metres of the main deposit identified. The landowner reported an investigative drilling project at the site 'in her father's time' where there is a small 'pond' area. Although dry on my visit she described water flowing across the field on occasion. The report on this investigation is within Geological Survey Ireland records on GOLDMINE and delineates a small mixed clay deposit. It has not been extracted and no palynological dating has been done on it. Despite some unexposed geological interest it is considered that there is insufficient to merit County Geological Site recognition.



The old clay pit at Knockgrafton.

#### Ballydrehid

Geological Survey Ireland records for ball clay (or pipe clay) deposits around Caher include Ballydrehid as a site where there was some extraction in the past. Inspection of the area indicated no extant site worthy of County Geological Site status, since the former pit has effectively been built on with a series of houses and workshops. There is a new pit adjacent to the site, but it is apparently working glacial deposits rather than clays.

#### Loughloghery

Ball clays were also worked in this townland, but there are no extant exposures and no trace of the deposits or workings within arable and grass fields. Some small quarries close to the sites of clays were examined and were found to be overgrown limestone quarries of no special interest.

#### Poynstown

Desk study reports for the IGH3 Carboniferous to Pliocene Palaeontology Theme from before 2002 had recommended Poynstown and the Coalbrook Band as an important site for the dating and correlation of the Slieveardagh Coalfield succession by means of non-marine lamellibranchs (small freshwater bivalve shell fossils). Unfortunately, locality information in the relevant literature is rather imprecise but is narrowed down to the area of Halfhandkerchief Wood in the Coalbrook

Demesne. The site is now a Rehab centre with a number of relatively modern buildings. No exposures survive. The landowner was contacted and he said there was no former quarry or exposures on the site though a neighbour who was involved in building on the site described there just being some 'slig'. This is a local term for the shaley deposit of very broken-up loose weathered rock, which can easily be dug to make farm tracks and fill. There was another small woodland to the east of the road (Beech Wood) marked on the Ordnance Survey six inch to the mile map but this has been cleared and turned to grazing land. It is possible some former small pit here was removed in the process.

It is most likely that Murrough O'Brien, then Director of Geological Survey Ireland provided samples to R.M.C. Eagar for his 1962 paper on this fauna from some temporary exposure that has long since been degraded, vegetated or built on. There is no clear site sufficient to merit County Geological Site status surviving here. If a new exposure in the locality was excavated then it could be assessed but this is unlikely to occur.



Poynstown site.

#### **Ryninch Upper**

There is a published record (Weir 1975) of a rare Silurian age shelly fauna collected earlier on from a debris flow conglomerate from Ryninch Upper Townland, about 2 km north of Ballina on the shores of Lough Derg. It was comparable to the CGS of Ballycar in County Clare. This conglomerate was searched for by M. Parkes in around 1991 and not traced. A revisit for this audit failed to find any obvious new evidence of pits or works which might have re-exposed the original very localised conglomerate.

#### Knockshigowna

The Silurian inlier of Knockshigowna was originally listed in the Master Site List after being considered as a geological NHA in terms of representation and completeness, although it was not selected as an NHA proposal in Irish Geological Heritage Programme work by M. Parkes on the IGH2

Precambrian to Devonian Palaeontology Theme in the late 1990s. It was revisited as part of this audit and both old and new exposures considered. The original farm pits which had been exposed in around 1999-2000 have long since been filled in by the landowner. There are some conjoined recent pits on the northern ridge and although these could be defined as a CGS to represent the geological interest of this small Silurian inlier, they are already being backfilled as they are worked and given the weathering speed of the shaley lithology, they will very quickly be unavailable. There are almost no natural exposures available on the hill, although there are a few small exposures of the Fairyhill Conglomerate on the very summit of Knockshigowna. It is considered overall, that there are insufficient durable exposures of interest to merit including Knockshigowna as a County Geological Site. This could change in future if major changes or quarries were opened to provide a more securely defined CGS.



The Knockshigowna site locality is in poor condition, and thus not listed as a CGS.

#### **Birdhill Quarry**

Irish Cement has a quarry less than 2 km northeast of Birdhill village. It provides silicate rocks from Silurian slates and greywackes which are ground up with a greater proportion of limestone to make up the mix for cement in the Mungret plant in Limerick. Compared to other exposures of Silurian rocks in Latteragh Quarry, Fantane Quarry, Reafadda Quarry, Carrigatogher M7 Road Cut and others this is relatively poor and was not selected for CGS status.

#### **Glenbeha Springs**

Glenbeha springs are located 3 km to the southwest of Roscrea town centre, in the townland of Ballycrine. The Springs Public Water Supply is the main groundwater source for the town of Roscrea, being gravity-fed from the source to the town network. The springs were developed in the 1950s, with upgrade works completed in 2002. As the source comprises two enclosed springs on either side of a laneway, it was considered that they might be of significance hydrogeologically. However, the springs are a set of straightforward contact springs, issuing from the ground where the bedrock meets the surface. They are not unique hydrogeologically therefore, and were not included as a County Geological Site on this basis.



One of the springs at the Glenbeha Springs site.

#### **Keeper Hill**

Keeper Hill was surveyed as the mountain was known to have been a nunatak during the last glaciation, where a portion of the top of the mountain poked through the surrounding glacier ice. As well as this, the ridge has a corrie on the northeastern side. Upon visiting the mountain it was seen that the corrie seems quite old, and does not seem to have been active during the Nahanagan Stadial, which means the backwall cliffs are not that spectacular and there are no well-developed moraines or tarn lake in the corrie floor. As well as this, evidence for the mountain being a nunatak is difficult to see, even with a trained eye, as there are no well-defined scatterings of erratic boulders and a related trimline above which these are absent. From this, the mountain was not included as a site.



Keeper Hill, here viewed from the Silvermines.

#### Lisheen Miocene site

A Miocene site at Lisheen was originally listed in the Tipperary Master Site List, whereby an occurrence of 'clay and lignite in a doline' was recorded, from mine exploration records deep below ground level. In consulting the original reference for the record, which was an academic paper from a Geological Society Special Publication from 1997, it was discovered that the record of actually only of deep (40 m +) karstification of limestone identified from a mineral exploration borehole, and the resultant palynological analysis of organic clays in the depression suggested a middle Tertiary age. As this (now inaccessible) borehole is the only expression of the geological 'site', this locality is not therefore included as a County Geological Site.

#### Fethard

A Miocene site at Fethard was also originally listed in the Tipperary Master Site, whereby an occurrence of 'clay and lignite in a depression' had been noted by a geologist working in the area in the late 1970s. In consulting the original reference for the record, which was the Sheet 18 'geology of Tipperary' booklet, published by Geological Survey Ireland in 1996, it was discovered that the record of actually only of 'pre-glacial residual materials exposed briefly near Fethard in 1994'. Thus, as the site is no longer accessible on the ground, it was therefore discounted as a County Geological Site.

#### Longfordpass Bog

During research into Littleton Bog as part of this audit project, it was noted that during the investigations in the Littleton area in the 1950s and 1960s, a borehole into the peat was also completed at Longfordpass, an adjacent townland, and the deposits from there analysed. The site was visited to examine if anything of geological or hydrogeological significance can be seen there today, but the site only comprises an area of cutover bog, either reclaimed to wet grassland or reverting to scrub. Hence, this locality was not included as a County Geological Site.



The peat bog in Longfordpass Townland.

#### Garranakilka "Debris Flow"

As part of research by EPA Catchments Unit in 2017, a locality near Borrisleigh had been noted as potentially having an extensive, relatively recent debris flow on the ground, during remote sensing analysis of aerial photographs. This locality, in Garranakilka Townland, was visited in the field as

part of the county audit. The 'feature' is however no more than low terrace associated with a number of valley-side spurs being truncated by a meandering and eroding river, at the base of a deep valley. As the feature is not a debris flow and not particularly noteworthy geomorphologically, it is not included as a County Geological Site.



The truncated valley-side spur, forming a low terrace, at Garranakilka.

#### **Fantane River Terraces**

The locality around Fantane has long been noted for having a set of glaciofluvial terraces within, set within a deep valley. These features were examined in the field during the county audit, but it was seen that they form a relatively straightforward set of flat-topped, glaciofluvial features, common throughout the Tipperary landscape, and are in no way exceptionally noteworthy. From this, they have not been included as a County Geological Site.



The flat-topped river terraces at Fantane.

#### **Birr-Borrisokane Crag and Tails**

The area in north Tipperary between Birr, County Offaly, and Borrisokane, had been noted from remote sensing and Digital Elevation Model mapping research in the 1990s to have a fine set of crag and tails features standing proud above the landscape. When mapped out in the field, the features are actually quite subdued, with few having the classic 'crag and tail' geomorphology, and are not good examples of the feature compared to other localities like the Killough Hill County Geological Site in mid-Tipperary, or the renowned set of crag and tail features also designated as a site around Fore in County Westmeath. From this, and the fact that the features are best observed through the use of remotely-sensed imagery rather than in the field, the features and area have not been included as a County Geological Site.



One of the relatively 'flat' crag and tail features, at Carrigahorig, north of Borrisokane.

#### **Downamona Turlough**

A number of small turloughs occur in north Tipperary, and these were surveyed to examine if they were worthy of inclusion as County Geological Sites. That at Downamona is small, not well expressed, and has no easily seen spring or swallow hole features in the field. Given the fact that the feature is not geomorphologically significant, and has relatively mundane vegetation thereon also, it is not included as a County Geological Site.



The base of the turlough at Downamona.

#### **Garryard Turlough**

Also known as 'Spring Park Wetlands', this turlough is situated about 5 ks north of Borrisokane, and comprises two small wetlands separated by agricultural land and the Borrisokane to Portumna road. As the feature is quite mundane, with no spring or swallow hole easily visible, and as the wetland geomorphology and hydrology displayed is common across County Tipperary, it is not included as a County Geological Site.



The western wetland at Garryard Turlough.

#### **Suirville Quarry**

Though not included in the IGH7 Master List, Suirville Quarry just southwest of Golden was visited as it previously had an extensive set of faces and spectacular folds, when visited during fieldwork in 2002. The limestone in the quarry is, however, now exhausted, and flooded with groundwater; only a couple of low faces are still visible. As no features of structural, sedimentary or palaeontological interest are found in these low faces, it was not deemed worthy of County Geological Site status.



Suirville Quarry.

#### **Cloghleigh (South) Quarry**

Though not included in the IGH7 Master List, Cloghleigh Quarry just south of Golden was visited as it previously had an extensive set of faces and spectacular bedding, when visited during fieldwork in 2002. The limestone and overlying sands and gravels in the quarry is, however, now exhausted, and partially flooded with groundwater; and only a few low faces are still visible. As no features of structural, sedimentary or palaeontological interest are found in these low faces, it was not deemed worthy of County Geological Site status.



The one extant rock face remaining in Cloghleigh (South) Quarry.

#### Ballyduff / Clonfinane Bog

Situated 5 km southwest of Birr, Ballyduff / Clonfinane Bog is an active raised bog, and is a designated SAC (000641). It was visited as part of this audit. Areas of bog cut in the past are regenerating and stabilising. Access to the bog is not directly afforded from a public road. Two raised bogs (Arragh More Bog and Kilcarren-Firville Bog) are situated nearby, and following the site visits, these two bogs were considered a representative selection of raised bogs to be included as County Geological Sites.



Ballyduff / Confinane Bog.

#### **Killeen Bog**

Situated 3 km southwest of Birr, Killeen Bog is an active raised bog, and is a designated NHA (000648). Large swathes of cutaway bog (now regenerating) remain on the outer perimeter of the bog. The bog was visited as part of this audit. The bog is bordered to the west by the L1075 road. The bog was not considered as a County Geological Site, as there are other raised bogs (Arragh More Bog and Kilcarren-Firville Bog) in the region that are equally representative of active raised bogs in north Tipperary.



Killeen Bog.

#### **Ardcrony Quarry**

Ardcrony Quarry is an active sand and gravel quarry situated in Coolderry townland, 1km south of Ardcrony crossroads. The quarry is operated by Ardcroney Stone and Paving Ltd. The sands and gravels are part of Ardcrony Esker, which traverses the landscape around Ardcrony in an east-west orientation. As large sections of Ardcroney Esker are included as a County Geological Site, Ardcrony Quarry is not included as an individual County Geological Site.

#### **Lisduff Quarry**

Listed as a Co Tipperary County Geological Site in the Master site List, Lisduff Quarry is situated 9 km northeast of Templemore, adjacent to the Cork-Dublin railway line. Lisduff townland (and the quarries therein) is situated in Co Laois, immediately east of the county boundary. There are two active adjacent quarries in operation: Campion's Quarry Ltd and Dowling Quarries Ltd.

#### Lough Avan

Lough Avan is a pNHA (000941), and is situated 6.5 km west of Borrisokane, and just north of Newchapel. The site was visited as part of this audit, however no significant geological or geomorphological features were observed to warrant inclusion as a County Geological Site. The site is recognised as an important wetland complex supporting a variety of habitats.



Lough Avan.

#### Killsheelan

For much of the 20<sup>th</sup> century, the South Ireland End Moraine (SIEM) was broadly accepted as representing the southernmost limit of ice during the last glaciation. Kilsheelan was one of the localities occupying this major 'moraine' feature. In recent years the significance of the SIEM at the 'ice sheet limit' has been revised and scaled back. It is currently accepted that the Irish Sea ice sheet extended much further south into the Celtic Sea during the Last Glacial Maximum, around 24,000 years ago, therefore following a visit as part of this audit, the site is not included as a County Geological Site,



Subdued topography at Kilsheelan.

#### Cashel

This is listed under IGH15 in the master list, i.e. as a mineral deposit, without further information. No such deposit is recorded in any of the standard reference works, including Cole (1922), or Geological Survey Ireland's mineral localities database on its digital data portal Goldmine. This listing appears to have been made in error.

#### Ahenny

Ahenny is listed for the Victoria slate quarries located on the south side of the valley of the Lingaun River, which separates Tipperary from Kilkenny to the north. The Ormonde slate quarry lies on the northern side of the valley and is included as a County Geological Site for Kilkenny. The quarries were significant producers in the 19<sup>th</sup> century, providing roof slate for Kells Priory in Co Kilkenny and Ormonde Castle in Co Tipperary. The Ormonde Quarry is the site of a sculpture park and is well maintained and readily accessible, albeit the lower part is flooded. It is sign-posted as part of a county heritage trail. In contrast, the two main Victoria quarries are both flooded, with steep faces and largely surrounded by trees and/or fencing. The quarry to the west abuts the rear garden of a recently built house and the ruins of a tramway building are also present in the front garden of this house. However, access was not available during the site visit. Since the Victoria quarries are neither maintained nor readily or even safely accessible, it is suggested that they be omitted. The Ormonde Quarry can serve as a well-maintained and accessible example of slate quarries in the Lingaun valley.



Eastern quarry, Victoria Quarries, Ahenny.

#### Ninemilehouse road section (Slievenamon)

This road section on the east side of the N76 at Brittas, is listed under IGH10 (Devonian). GEOLOGICAL SURVEY IRELAND's 1:100,000 bedrock map suggests that the conglomerates and sandstones of the ORS Carrigmaclea Formation are in unconformable contact with the greywackes and slates of the Silurian South Lodge Formation at the southern end of this section. However the ORS is absent from the outcrop, which comprises only green-grey psammite and siltstone of the South Lodge Formation. Large outcrops of ORS can be observed further south, west of the road, though not in contact with the Silurian. On its own, the heavily overgrown outcrop of Silurian strata is not particularly interesting. The unconformable contact between the ORS and underlying Silurian strata is spectacularly displayed at the Devilsbit CGS site. Therefore the Ninemilehouse section is omitted.



Ninemilehouse road section, view from west side of road, section hidden by vegetation



Detail of Ninemilehouse road section: Silurian greywackes and siltstones

#### Gorteenadiha (Silvermines district)

Gorteenadiha was not listed on the Tipperary master list but was added as a possible site given its historic significance in the Silvermines district as being primarily known as a copper mine, in contrast to the other, lead-zinc-silver mines in the district. Gorteenadiha is south of the Silvermines-Shallee road, immediately west of Garryard. It was first worked in the early 18<sup>th</sup> and early 19<sup>th</sup> centuries and mining continued into the 20<sup>th</sup> century. Veins were worked for copper, lead and silver both from at the surface and from several small pits. Numerous shafts and an adit are marked on old maps and the site contains the remains of two small concrete buildings from the more recent period of mining, as well as scattered small spoil heaps. However, the site is heavily overgrown and contains nothing that is not better displayed at Ballygown or Shallee.



Gorteenadiha mine site, view south from Silvermines – Shallee road.

#### **Gortmore (Silvermines district)**

Gortmore was not listed on the Tipperary master list but was added as a possible site given its prominence in the Silvermines district. The Gortmore TMF was built by Mogul to store the fine waste slurry or tailings produced by its large-scale underground mining at Garryard, 2 km to the east. The TMF was completed in 1967 and tailings were pumped from Garryard via a pipeline. Following closure of the TMF, the surface layer of tailings slowly dried out and several major dust blows occurred, giving rise to concerns from residents. The TMF has subsequently been remediated through capping and development of a vigorous grass sward on its surface, eliminating the risk of

further dust blows. While the TMF is a significant modern mine feature and its remediation is of some engineering and environmental significance, is not suitable for listing as a CGS in its own right.



Gortmore TMF

#### Lickfinn (Slieve Ardagh coalfield)

The Slieve Ardagh coalfield was not included in the original Tipperary master list. Lickfinn was included in the audit as one of the mine sites in Slieve Ardagh known to contain some surface mine features. The Lickfinn mine was one of the last mines to operate in the Slieve Ardagh coalfied, between 1978 and 1983. The mine site occupies 1.6 ha by the side of the road, 2 km northeast of Ballynunty and 5 km southwest of Gorteen. The site is small as the processing operation was carried on at Gorteen. Two adits on the site, one the main decline adit and the other a return drift for circulation of air, are capped. The site also contains the remains of the steel-framed corrugated iron-enclosed workshops and a large waste heap. Other small buildings have been removed in recent years, as have the remains of the winch system and loading platform. The site appears to be in use as a yard for storing materials. There is little of interest on the site apart from the waste heap but this does not justify CGS status.



Lickfinn site with waste heap in the background.

#### Foilacamin

The Slieve Ardagh coalfield was not included in the original Tipperary master list. Foilacamin was included in the audit as one of the mine sites in Slieve Ardagh known to contain some surface mine features. It lies at the northeastern end of the northern side of the coalfield. There are two separate sites at Foilacamin, the old 19<sup>th</sup> century colliery site to the north and the opencast site, also known as Knockanglass, in the south. The old colliery site (1 ha) is now part of a private house

and garden property, with the main Foilacamin shaft (capped and bricked up) located in the garden. The Foilacamin opencast site was opened in the late 1960s by Ballingarry Collieries Ltd. but closed within a year. The excavations here are extensive and the site contains significant volumes of waste but no exposures of coal. Neither they nor the very limited remaining 19<sup>th</sup> century mine features warrant CGS status.



Foilacamin: Knockanglass opencast workings, view southwestwards.

#### **Cloughjordan Esker**

Whilst not listed on the Master Site List, Cloughjordan Esker was visited as part of this audit with a view to including the feature as a County Geological Site. The esker in the locality originated during the deglaciation events that formed the eskers further west and northwest near Ardcrony. The esker field continues from Ardcrony 10 km east to Cloughjordan, and therefore Cloughjordan Esker is therefore included in the Ardcrony Esker County Geological Site.



#### Marlfield

This is now one site that combines the St. Patricks Well, and an adjacent lake, near Clonmel, in to one site. The site now includes the formally laid out area that includes a small man-made pond, a walled "well" that issues into the pond and the ruins of a small chapel or oratory. The pond discharges southwards and the water feeds Marlfield lake, which was created by damming the southern end in 1773 to power a mill.

#### 2. Tipperary Council policies regarding geological heritage

The completion of this geological heritage audit will ensure that the next County Development Plan will be able to incorporate a robust selection of sites that are important in County Tipperary. Whilst some are candidates for NHA designation in the future if the geological NHAs ever become a reality, the sites that are purely of local importance are included in the audit results.

The policy of Tipperary County Council, as laid out in the current [December 2017] County Development Plan as varied from the previously separate North and South Tipperary Plans is quite straightforward, which is very positive for geological heritage. The completion of this Audit in 2019 fulfils this objective:

*SO7-5 It is an objective of the Council, subject to resources, to undertake a review of Geological Sites in Tipperary in association with the Geological Survey of Ireland over the lifetime of the Plan (as varied).* 

The County Development Plan also recognises the economic importance of the extractive industries in relation to mining and quarrying, which can be the primary reason why and how much geological heritage is identified and created, through the human dependence on Earth's resources.

#### 5.7 Extractive Industries

The county contains extensive reserves of sand and gravel, which are key natural resources and assets. Quarrying provides direct and indirect employment in many areas of the county. The county also contains rich underground minerals including lead and zinc ore. The Council will facilitate the development of extractive industries, while ensuring that the environment and rural and residential amenities are protected.

#### Policy ED11: Minerals, Mining and Quarrying

It is the policy of the Council to have regard to the Quarries and Ancillary Activities, Guidelines for Planning Authorities, (DEHLG 2004), and promote the extraction of minerals and aggregates, where such activities do not have a significant impact on the environment, landscape or residential amenities of the area.

In addition, the List of Protected Structures includes some mining or mine related buildings at Shallee and Silvermines.

There are detailed, positive policies regarding peatlands which are essentially the youngest and most recent geological deposits covered in these policies:

#### 7.3.4 Peatlands

In Tipperary, the following bogs are designated as SAC's under the EU Habitats Directive: Ballyduff/Clonfinane Bog, Kilcarren-Firville Bog and Redwood Bog and NHA's under the Wildlife Act: River Little Brosna Callows, Arragh More Bog, Ballymacegan Bog, Killeen Bog, Monaincha Bog/ Ballaghmore, Cangort Bog, Scohaboy Bog, Lorrha Bog and Nore Valley Bogs. In addition to these designated bog areas there are significant cut-over and partially cut-over peatland areas in the county, particularly in the mid-west of the County.

The National Peatlands Strategy 2015 published by the Department of Arts, Heritage and the Gaeltacht sets out objectives for bogs and peatlands so that they may be managed responsibly in order to optimise their social, environmental and economic contribution to the well-being of this and future generations. It is acknowledged that Ireland's peatlands will continue to be used for many purposes including agriculture, development, peat extraction, forestry, conservation and amenity.

Ireland's peatlands are a unique habitat in a European context and there are a number of sites in Tipperary which have been designated SACs and are subject to conservation management plans. These areas offer opportunities for tourism, education and research purposes. Peatlands which are not protected by European designations can provide a resource for turf cutting, renewable energy development, forestry, agriculture, nature conservation and recreation. The Council will support diversification of use of such peatlands in the county, whilst ensuring the appropriate management of same to ensure the conservation of their ecological, archaeological, cultural and educational significance. Where new development is proposed on areas of peatland in Tipperary, the Council may request the landowner to support his/her proposal with a Master Plan for the entire peatland area in their ownership. A peatland master plan shall be to the satisfaction of the Council and shall identify the natural, infrastructural and cultural attributes of the area and shall set out the proposed use of the entire area, with consideration to rehabilitation and economic, environmental and recreational potential and uses.

#### Policy LH10: Peatlands

It is the policy of the Council to have regard to the National Peatlands Strategy 2015 and to ensure the conservation of peatlands which are designated sites as set out in Appendix 4. The Council will support agricultural diversification, renewable energy development and the development of tourism and community recreational facilities in peatland areas, where appropriate, and where it is demonstrated that such developments would not significantly or adversely impact on the ecological and environmental sustainability of such sites.

#### 3. 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 pNHA sites. In these areas, the geological heritage enhances and cements the value of these sites for nature conservation, and often requires no additional designation of actual land areas, and ideally, a 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 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 County Tipperary, the Kilmastulla Meltwater Channels are examples of these.

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 County Tipperary. For example, views within the Knockmealdown, Galtee, Silvermines and Arra Mountains should be preserved as best as possible.

A lack of awareness in the past, has led to the loss of important geological sites and local character throughout the country. In County Tipperary a Landscape Characterisation Assessment was completed (2016) and incorporated into the County Development Plan. This provides a tool for planners to help maintain the character of the County and informs things like wind energy strategy. However, it is a methodology that could be considered to place inadequate value on the underlying geodiversity in defining landscape character areas. The Strategic Environmental Assessment within the County Development Plan also provides tools. In addition, the now routine pattern of consultations with Geological Survey Ireland, either by the planning department or by consultants carrying out Environmental Impact Assessment, plus strategic environmental assessment (SEA), has greatly improved the situation.

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 many 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. In this audit, working quarries like Kilfeacle Quarry, Laffansbridge Quarry and Cloghleigh Quarry are now included as County Geological Sites in County Tipperary. These issues are briefly explored in a set of Geological Heritage Guidelines for the Extractive Industry, published jointly by Geological Survey Ireland and the Irish Concrete Federation (Gatley and Parkes 2008; Parkes and Gatley 2018).

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 with sediments. 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.

One of the phenomena of the so-called 'Celtic Tiger' economic boom was an extensive motorway building programme. These larger routes, with gradient and bend limitations frequently generated new cuttings. Partly as a result of the promotion of geodiversity by the Irish Geological Heritage Programme in responding to planning enquiries for these routes, there are many where rock cuttings have been left as a feature of interest, whereas in the past civil engineering mindsets would have graded every slope to 45° and covered them with soil and grass. Many of these major cuttings provide significant new County Geological Sites such as Carrigatogher and Touknockane in Tipperary. However, a degree of maintenance may be required to stop natural revegetation by trees obscuring the geological interest over time.

#### Waste dumping

An occasional problem throughout the country, including in County Tipperary, 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 in quarries or disused gravel pits, 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. County Tipperary was included in a national scheme for Groundwater Protection in 2012, 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 County Tipperary.

#### 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 or other major developments. 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. It may also contribute to road safety by providing diversity of surroundings to maintain drivers' attention.

#### **UNESCO Global 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 were elevated to full United Nations Educational, Scientific and Cultural Organisation (UNESCO) in 2015. 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. Geopark branding therefore helps promote the geological heritage resource so that the community can benefit from it. However, significant management support from local authorities, such as the County Council, has proven to be virtually essential across the network.

In Ireland there are three UNESCO Global Geopark members. One is the cross-border Marble Arch Caves UNESCO Global Geopark in Fermanagh and Cavan [www.marblearchcaves.net and www.cavancoco.ie/marble-arch-caves-global-geopark]. The Copper Coast UNESCO Global Geopark in Waterford also joined the Network in 2001 [www.coppercoastgeopark.com]. A now well established addition has been the Burren and Cliffs of Moher UNESCO Global Geopark in County Clare [www.burrengeopark.ie]. In addition there are aspirant groups exploring the work and infrastructure required for applications in other areas, the most advanced of which is Joyce Country and Western Lakes Geopark in Mayo and Galway.

The bar to reach UNESCO Global Geopark status is set very high and to consider achieving this would require a sustained commitment from Tipperary County Council, as well as considerable investment in geological tourism, trails, education and protection in order to demonstrate the functions of a Geopark. Even if that investment was delivered, there are rules on a national territory basis about how many candidate Geoparks can apply at any one time. This process and support for candidate Geoparks is provided by the Geological Survey of Ireland and the Geological Survey of Northern Ireland.

At present (2019) the authors do not consider there is any coherent area within Tipperary (or even if an adjoining county was added into the geological picture) that makes a good candidate for Geopark status. Whilst Tipperary clearly has a large range of County Geological Sites, they are geographically well spread and thematically very diverse. There is no especial richness in any particular type of geological site that would create the potential 'uniqueness' to consider the Geopark approach.

#### 3.1 Geological Heritage Theme - The Southern Irish End Moraine

Much confusion has existed in the past in Irish glacial literature about the exact positioning of glacial features. Whilst the interpretation of drumlins, eskers and glacial deposits are bound to vary over time and between different researchers, there has been remarkably little agreement on the nature and distribution of the actual landforms and deposits. This is problematic, as a 'glacial map' should form the basis of any reconstruction. Surely the exact position of the features should never be in doubt, as the process only involves their placement on a map !

However, systematic and consistent mapping at the ice sheet scale has only recently been achieved in Ireland. It is thus no surprise that the historical reconstructed behaviours differ greatly. Previous studies were conducted at different scales, with different authors working in the same area including some features and disregarding others. Hence the models built by each researcher were bound to differ, and it is difficult to compare these with each other as features seen as important by one researcher are disregarded by another.



Figure 1 Left: General Quaternary geomorphology map of Ireland, as modelled pre-1990s. Right: Montage of General ice movements as interpreted during the 1960's and early 1970's. A) Interglacial sites B) Munsterian ice flows. C and D) Midlandian ice flows (all maps from Davies and Stephens, 1978). Note the 'Southern Irish End Moraine' stretching across the country from Limerick to Wicklow, through Tipperary.
Thus, before the 1990s, it had been assumed that the glacial landforms of Ireland were broadly grouped into two provenances associated with two Pleistocene cold phases, termed the Munsterian (older) and Midlandian (younger), which were separated by the 'Southern Irish End Moraine'. Further north, the 'Drumlin Readvance Moraine' separated the area comprising fresh, 'Midlandian' landforms into those formed by drumlin-moulding ice, and those not. Detailed field mapping in the 1990s showed that no such features existed on the ground and the features have since been rejected based on sedimentological evidence and on a stratigraphic basis.

It is now widely accepted that the entire island of Ireland was smothered by an ice sheet during the last glacial cycle, with ice limits extending well offshore to the south and west.

## 3.2 Geological Heritage Theme - Subglacial bedforms in County Tipperary

The ice sheets that covered County Tipperary 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 drumlins or crag and tails. 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.



Illustration showing the formation of drumlins under a moving ice sheet.

The ice sheet flowed generally north to south across Tipperary, a fact illustrated by the orientations of the drumlins and crag and tails, which are aligned either northwest to southeast or north to south 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 crag and tails and drumlins. At this time peat also formed in many localities between the ridges.

## 3.3 Geological Heritage Theme - Karst in Ireland, and in Tipperary

Approximately half the area of Ireland is underlain by Carboniferous limestone. Consequently, karst is a significant aspect of the Irish environment. The karst of upland areas such as the plateaux of the northwest such as Ben Bulben and areas such as the Burren, has been long noted and extensively researched. However, little work has been done on the lowland karst, which forms a much more complex system as this karst interfingers with and influences and is influenced by glacial and postglacial sediments of varying thicknesses. This is essentially partially buried karst, and such a system underlies the majority of the lowland in northern and mid-Tipperary.

Karstification involves the enlargement of rock fissures when groundwater dissolves the fissure walls as it flows through them. Therefore water disappears down vertical passages, rather than moving laterally as a surface stream. Fissures become master fissures and *swallow holes*, or sinkholes, are created. A swallow holes is basically an opening in the bed of a river that flows over limestone. At this opening the river takes its course underground and winds it way under the ground surface. Some swallow holes develop into small to medium sized closed depressions, or *dolines*; water moving laterally subsurface as underground rivers forms *caves* from fissures. Other features formed include: *dry valleys*, where streams once flowed at surface and then disappeared underground; *springs*, where water reappears at surface from underground fissures; and *estavelles*, which act as swallow holes during dry portions of the year and springs during wet. Karst features can even be recognized on what may seem the most bland rock outcrop, with many limestone surfaces pitted with hollows or runnels, collectively termed *karren*.

Upon reading this it can correctly be assumed that the lowlands of Tipperary, therefore, existed in the Palaeogene and Neogene Periods as merely an extensive karst basin, with sporadic hums (hills). The ice sheets of the Pleistocene would then have planated and smoothed the basin, causing the low-relief, almost bowl-shaped lowland in existence today.

## 3.4 Geological Heritage Theme - The Littletonian

The Holocene is the current geological epoch, which began approximately, 11,650 years before present, just after the last glaciation. The Holocene and the preceding Pleistocene together form the Quaternary Period of geological time, which began approximately 2.58 million years ago. The Holocene has been identified with the current warm period, known as MIS 1, and is considered by some to be an interglacial period within the Pleistocene Epoch.

In Ireland, the Holocene is termed the Littletonian Period stratigraphically, and this epoch corresponds not only with a warming climate but also with the rapid proliferation, growth and impacts of the human species worldwide, including all of its written history, technological

revolutions, development of major civilizations, and overall significant transition towards urban living in the present.

The naming of the Holocene as 'Littletonian' in Ireland was achieved in the 1950s, when a deep bore was completed in Leigh Townland which is within the central portion of Littleton Bog, and the 7.5 m depth of peat studied from the core was seen to have a complete, intact pollen record of the vegetation of the locality from the end of the last Ice Age to the present day.

# 4. Summary and Recommendations

# 4.1 Proposals and ideas for promotion of geological heritage in County Tipperary

This section examines the existing objectives in the County Tipperary Heritage Plan (2017-2021) relating to geological heritage in any way, and provides specific suggestions as to how these may be implemented, supported or enhanced by the audit of geological heritage sites in the county.

## **Objective 1: PROMOTE AWARENESS AND APPRECIATION OF THE HERITAGE OF TIPPERARY.**

**1.1** Enhance and promote access to and experience of heritage sites across the county including monuments, built and cultural heritage and natural heritage sites.

Audit action: The Audit adds to the knowledge of heritage sites in the county, the geological sites being of equal parity to any other type of heritage, yet often being unknown or unappreciated from a lack of awareness of geology in society as a whole.

**1.2** Encourage participation in heritage initiatives and projects at community level including through schools, youth groups, voluntary groups and statutory bodies. Hold a community workshop in each Municipal District during the first 12 months of the plan to engage directly with groups working on heritage projects in the area.

Audit action: Whilst not an obvious choice for community engagement, the identification of specific issues at County Geological Sites in the audit may provide a stimulus for a practical workshop to manage a site through clean-up, vegetation clearance, signage and access works etc.

**1.3** Continue to support heritage events and festivals throughout the year particularly during Heritage Week, Biodiversity Week and others where local buildings, archaeology, food, nature, sport music and local history are celebrated.

Audit action: The authors of this audit are willing to contribute to Heritage Week events or other occasions – this could be through leading field visits in person, giving lectures, radio interviews, providing an image based 'popular' exhibition on the geological heritage or other means.

**1.4** Produce a bi-annual heritage newsletter/ezine targeting awareness, heritage events, initiatives and projects around the county.

Audit action: The authors of this audit can provide additional publicity articles or materials to promote the audit and assist with this objective.

**1.5** Produce a suite of booklets posters and an annual calendar over the life of the plan that highlight some of the thematic aspects of our county's heritage.

Audit action: The authors of this audit can provide materials supplementary to the audit that will help achieve this objective. For example a focused calendar on the landscapes and geological heritage of the county would be an easy task using audit imagery.

**1.7** Improve content of the website to be a resource containing heritage information, advice, details on current projects and actions being taken for heritage around the county

Audit action: The audit will provide new content for the website, and the authors can provide tailored variations of audit content for the purpose. Equally a link can be made direct to the geological heritage pages and web-maps on the Geological Survey Ireland website and on the Ordnance Survey's Geohive.

**1.8** Pilot a County Heritage Open day, where selected buildings or sites of heritage interest, not normally publicly accessible are open to the public for a specified time with a view to making it an annual event.

Audit action: The audit fieldwork may identify sites where the landowner is willing to make a site accessible for a limited time in such a scheme, even if the site is private the remainder of the time.

**1.9** Develop a media presence in local newspapers and radio promoting awareness of built and natural heritage sites and other heritage matters.

Audit action: The authors of this audit are willing to contribute to media profile of heritage in Tipperary through giving radio interviews, providing tailored audit content material or other means.

**1.11** Hold an annual awareness day that showcases aspects of the heritage of the county. *Audit action: The authors of this audit can provide additional publicity articles or materials to promote the audit and assist with this objective.* 

**1.12** Utilise technology to actively promote heritage sites and projects in the county. *Audit action: Audit data may help stimulate projects with or provide data for web-based promotion of heritage in the county.* 

**1.13** Where possible support collaborative projects with stakeholders and N.G.O's and other agencies or bordering counties to promote awareness of shared heritage sites. *Audit action: For some geological heritage sites such as the caves and karst sites, the authors will promote the audit and results with a relevant NGO – the Speleological Union of Ireland. Fieldwork may identify suitable sites for collaborative projects such as 'cave clean-ups', with cavers providing cleaning of a specialised environment, and the council providing resources to remove the dumped waste.* 

**1.14** Support the work of the Tipperary County Museum with Transport Infrastructure Ireland (TII) in developing an exhibition of key objects found in TII road excavations in Tipperary, and to promote the final archaeological reports in Tipperary Studies and Tipperary County Museum and as an online resource. *Audit action: As a marginal element of this objective, it is suggested that the geological heritage of new road cut sites is also promoted in parallel with archaeological finds to further public interest and make best use of audit data for such sites.* 

**1.15** Work with Tourism Office and Sports Partnership to include heritage interpretation along recreational routes/greenways and blueways being developed in the county.

Audit action: The audit data may contribute to this objective where sites co-incide with any proposed tourism/activity routes in Tipperary.

## **Objective 2: PROMOTE ACTIVE CONSERVATION OF THE HERITAGE OF TIPPERARY.**

**2.1** Hold regular training events that will provide advice and guidance to local groups on heritage related topics for e.g. historic properties, graveyards and natural heritage sites.

Audit action: The authors of this report may be able to provide specialist input to such training events, relating to geological heritage, or to specific elements like karst, eskers, peatlands, mining heritage.
2.2 Support staff training within the local authority on matters relating to built and natural heritage.
Audit action: The authors of this report may be able to provide custom specialist input to staff training events, relating to geological heritage, or to specific elements like karst, eskers, peatlands, mining heritage.

**2.6** Encourage the re-use of historic buildings within the county and promote awareness of best practice examples

Audit action: The authors of this report have specialist knowledge of mining heritage and the conservation of buildings related to it, and may be able to contribute if requested.

# **Objective 3: SUPPORT GATHERING AND DISSEMINATION OF INFORMATION ON THE HERITAGE OF TIPPERARY.**

**3.1** Audit the existing body of information that has been gathered between North and South Tipperary and do up a programme for research for the lifetime of the plan targeting the main gaps in our bank of knowledge.

**3.2** Audit material and artefacts from Tipperary that are housed in National Institutions such as the National Museum, National Library and National Archives and promote awareness of these collections. *Audit action: The geological heritage audit is concerned with sites. In the case of some fossil and mineral sites and possibly with building stone sources, there may be material held in the Natural History Museum (NHM) collections in Dublin. An enquiry to the NHM will provide data on these fossil and mineral collections. Similarly an enquiry to GEOLOGICAL SURVEY IRELAND will provide data on such holdings (e.g. plant fossils from Slieve Ardagh collieries) but in both cases they may be extensive.* 

**3.3** Develop a series of heritage worksheets aimed at primary school level relating to aspects of the counties heritage such as flora and fauna, built heritage etc

Audit action: The audit authors may be able to contribute custom content during the timescale of the audit in 2019, or possibly afterwards on request.

**3.4** Make data gathered by the Heritage Office available to departments within the local authority doing interpretation or drawing up guidelines and plans.

Audit action: As with 2.5, the authors of this report may be able to provide custom specialist input to council staff for specific actions.

**3.6** Establish a Tipperary Folklore project with a view to gathering the folklore of the county and having a permanent record and resource of this material available.

Audit action: The audit data may help focus such a project on specific targets like the coal mining heritage of Slieve Ardagh.

**3.7** Develop a programme of oral history around projects on heritage sites which can be used to enhance interpretation of these sites.

Audit action: Some of the authors have been heavily involved in mining heritage and this is one area where oral history projects may be specially relevant, between the historical metal mining at Silvermines, the historic coal mining in Slieve Ardagh and especially in capturing recent heritage of modern mining at Lisheen, where no specific heritage sites remain after modern environmental post-mining works.

# 4.2 Specific ideas for projects

## **DVD** projects

DVDs which focus on 3D animations and interactive of aspects of places such as the Galtee Mountains geological landscape, and in particular sites such as the Rock of Cashel, would be worthy additions to the geological education resource.

## Leaflets

Few existing leaflets on the geological heritage of County Tipperary are known, other than the Geoschol one included as an appendix here. There is some scope for other and different leaflets. Any geo-leaflets produced could simply be made available as PDF downloads on the Council's website to avoid large costs of printing. Such a format has been adapted by the Cabragh Wetlands committee, whereby the booklet guide to the site can be downloaded from their website (<u>http://www.cabraghwetlands.ie/blog/wp-content/uploads/2018/04/A4-Cosmic-Walk-pdf.pdf</u>). There are some funding schemes that are particularly suited to such publications when produced by local groups. The authors can advise any potential communities looking to create local leaflets or guides.



## Guides

The 1:100,000 map report for Sheet 18 (Archer, Sleeman and Smith 1996) is the principal Geological Survey Ireland coverage of County Tipperary and the southern part of the county is on Sheet 22 (Sleeman and McConnell 1995) and both are an essential resource. There is little coverage of Tipperary in other broad fieldguides to the geology of Ireland or regions. The Geology Department in University College Cork published a useful map and report that covered Slieve Aughty, Silvermines, Devilsbit Mountains and Slieve Bloom (Brück *et al.* 1985). The Irish Quaternary Research Association (IQUA) also published a specific guide to the Galtee Mountains in 1979, as a part of their annual field excursion.

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 main content of this report would distil into a good general guide to the geological heritage of County Tipperary, in a broadly similar style to those books produced for Sligo, Fingal, Waterford, Roscommon, Clare and following audits in those counties.



#### 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 one discrete place, such as those at the Galtee Mountains trailhead, is preferable 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 Tipperary Council Offices, County Library branches or other venues. The model followed was that used for Carlow, Dun Laoghaire-Rathdown, Waterford, Wicklow, Longford etc. Images of those and other similar ones can be seen on the Geological Heritage section of the Geological Survey Ireland website [www.gsi.ie]. It is our experience that when used in locations such as County Offices they can provide a popular

attraction that enhances ordinary business visits to conduct other affairs. These may reach a greater audience than an advertised exhibition in a specific location.

## 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 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, to link sites in any coherent ways, other than simply by their county.

## Earth Science Ireland Group and magazine [www.earthscienceireland.org]

Earth Science Ireland was an all-Ireland group promoting awareness of Earth sciences and supporting educational provision in the subject. A main vehicle for the efforts was the twice a year magazine *Earth Science Ireland*. Sadly, this organisation has ceased operating but the magazines remain available online, and include various articles relating to Tipperary.

## 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 County Tipperary is already part of the available material (see Appendix 8). Working links to the Heritage section of County Tipperary Council's website, 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 County Tipperary geology and geomorphology will assist many users and researchers into the future. However, the literature is very specialist in nature, such that a geological heritage section with a select bibliography pdf on the Heritage web pages for Tipperary might suffice for most users with a general interest in their local heritage.



#### Maps

It is hoped that geological heritage sites as a data layer might be adopted by the Ordnance Survey of Ireland in their future map editions of the 1:50,000 Discovery Series, for all counties where an audit has been completed (similar to the East-West Mapping maps of Wicklow, Mayo etc. which include such data from Geological Survey Ireland).

#### Heritage Council Heritage Viewer

HeritageMaps.ie is a web-based spatial data viewer, co-ordinated by the Heritage Council, and working with the Local Authority Heritage Officer network, which focuses on the built, cultural and natural heritage around Ireland and off shore. This viewer allows you to look at a wide range of built and natural heritage data sets in map form. The outlines of and data on each individual County Geological Site in Tipperary should be made visible on the HeritageMaps.ie viewer once the audit is completed.



# 5. A summary of the Geology of County Tipperary

## 5.1 Paragraph summary

County Tipperary has five main episodes in its geological story. The first, and oldest, of these is represented by the Arra, Silvermines, Slievenamon and Galtee Mountains, where older Silurian marine rocks, from around 425 million years ago, are found in patches where erosion of the uplands has stripped off the younger Devonian sandstones and conglomerates from river environments, which overlay them. These Devonian rocks, of the second stage, do surround the Silurian rocks in these mountain ranges, as well as forming most of the Knockmealdown Mountains and the Slievenamuck Ridge. Over most of the county, the plains are founded on the third episode, that of the Carboniferous Limestone from around 330 million years ago. These are shelf limestones from open marine environments. Following this period, in the Upper Carboniferous, shales, sandstones and coal were formed in the Slieve Ardagh Hills. A veneer of till and some esker ridges are the result of the third major episode, that of the more recent Ice Age.

## 5.2 Simple summary

The landscape of County Tipperary is a mix of lowland and upland terrain. The core portions of the Arra and Silvermines Mountains, Slievenamon Mountain and the Galtees, are formed of the oldest rocks in the county. These old rocks occur in several patches towards the centre of these mountain ranges where erosion has stripped away the younger rocks. These grey mudstones, siltstones and sandstones are Silurian in age, around 425 million years old (Ma), and were deposited on a deep ocean floor.

Surrounding these, and also forming the Knockmealdown Mountains and the Slievenamuck Ridge, are some Devonian age rocks, sandstones and gravels laid down by flash floods in a poorly vegetated environment. Both Silurian rocks and Devonian rocks are partly preserved because they have been lifted up by Earth movements in the Hercynian (also called the Variscan) orogeny, 380 to 280 million years ago.

Soon after the start of the Carboniferous Period, sea level rose to flood across these low plains. The first of the marine rocks to be deposited were dark grey fossiliferous mudstones, but above these is a series of thick grey limestones which underlie much of the low ground across the county. At certain levels these limestones are quite fossiliferous, with shells of brachiopods and nautiloids, corals, fragments of crinoids, and rarer fossils such as trilobites. Mostly these limestones accumulated as horizontal layers on a fairly shallow 'shelf' sea floor although some of the younger layered limestones, around 325 Ma, are much darker in colour and were deposited in considerably deeper water. Although the limestones mostly form low ground across the centre of the county, they are well exposed in various working and disused quarries and on some of the low hills in both the centre and south of the county.

Only in and around the Slieve Ardagh hills are there younger solid rocks, recording a time when the shallow sea was filled with deltas and swamps. In these sandstone and shale rocks there are coal seams formed from ancient forests. The land surface then emerged for nearly 300 million years and many of these rocks were eroded down to their present level. Only small parts of the country now remain covered by these coalfield rocks, primarily the Arigna district in Leitrim, the northern tip of

Roscommon and Slieve Ardagh and other, smaller pockets in Tipperary, around Fethard and east of Caher.

The most significant force to shape the form of the county as we see it today was the Ice Age which ended about 10,000 years ago. Large ice sheets several hundred metres in thickness covered the county for tens of thousands of years and eroded the rocks beneath. As the ice eventually melted away, the meltwaters reorganised the sediments into iconic landforms like eskers, adjacent to large fans and deltas of sand and gravel. Eskers were formed by sub-glacial rivers, that is, they flowed in tunnels at the base of the ice sheets. Some eskers are small and local within Tipperary, but the majority that traverse the county form extended networks and cross several counties.

Since the Ice Age, much of the exposed limestone in Tipperary has developed into what is termed karstified bedrock. Water solution of the rock formed some caves, such as Mitchelstown Caves, and swallow holes, such as Tincurry Sink near Caher. Where some larger, temporary lakes were formed when meltwater was prolific, unusual mushroom shaped stones were created by dissolution of the rock that was submerged. The northern tip of Tipperary forms part of the largest concentration of such mushroom rocks in Ireland. Geological processes continue to modify the landscape today, such as with seasonal flooding of the Shannon and Little Brosna River Callows.

| ACE      |                |               |  | IF THIS   |
|----------|----------------|---------------|--|---|
| (Million | ERA            | PERIOD        | EVENTS IN TIPPERARY  | TIMESCALE WAS   |
| Years    |                |               |  | Α   |
| Ago)     |                |               |  | DAY LONG  |
| 2.58     | Cenozoic       | Quaternary    | Several ice ages smothering Tipperary,<br>followed in the last 10,000 years by the spread<br>of vegetation, growth of bogs and arrival of<br>humans. Sculpting of corries in the Galtee,<br>Knockmealdown and Silvermines Mountains.<br>Deposition of (till) boulder clay in drumlins and<br>till plains, as well as sands and gravels in<br>outwash rivers, eskers, fans and deltas.<br>Dissolution of limestone beneath Quaternary<br>sediments. | The ice ages would<br>begin 38 seconds<br>before midnight |
| 23       |                | Neogene       | Erosion, especially of limestone. Caves,<br>swallow holes, cavities and underground<br>streams developing in the lowlands of south   | The Neogene<br>period begins at<br>11.52 pm               |
| 66       |                | Palaeogene    | and east Tipperary.<br>Deposition of sediments and associated<br>vegetative remains in cavities at Lisheen Mine.   | The Palaeogene<br>period begins at<br>11.40 pm            |
| 145      | Mezozoic       | Cretaceous    | Erosion.<br>No record of rocks of this age in Tipperary.   | 11.15 pm  |
| 201      |                | Jurassic      | Uplift and erosion.<br>No record of rocks of this age in Tipperary.  | The age of the<br>dinosaurs, starting<br>at 10.55 pm      |
| 252      |                | Triassic      | Desert conditions on land.   | 10.42 pm  |
| 299      | - Palaeozoic   | Permian       | No record of rocks of this age in Tipperary.   | 10.30 pm  |
| 359      |                | Carboniferous | Land became submerged, limestones with<br>some shales and sandstones deposited in<br>tropical seas across much of northernmost,<br>south and east Tipperary.<br>Limestones remaining today are pure and<br>unbedded in the majority, with smaller areas of<br>muddier limestones at the edges.<br>Shales and sandstones, with some coal seams,<br>deposited in Slieve Ardagh district.   | Inundation of land<br>by sea around<br>10.10 pm           |
| 419      |                | Devonian      | Caledonian mountain building.<br>Sandstones deposited around the edges of the<br>Knockmealdowns, Galtees, Silvermines,<br>Slievenamon and Arra Mountains.  | 'Old Red' Sandstone<br>deposited at<br>9.52 pm            |
| 443      |                | Silurian      | Shallow seas, following closure of the lapetus<br>Ocean. Greywacke and shales deposited in the<br>centre of the Knockmealdowns, Galtees,<br>Silvermines, Slievenamon and Arra Mountains.   | Starts at 9.42 pm   |
| 485      |                | Ordovician    | lapetus Ocean divides Ireland into two.<br>No record of rocks of this age in Tipperary.  | Begins at 9.28 pm   |
| 541      |                | Cambrian      | Opening of the lapetus Ocean.<br>No record of rocks of this age in Tipperary.  | Starts at 9.11 pm   |
| 2500     | Proterozoic    |               | Some of Irelands oldest rocks deposited in Mayo and Sligo.   | Beginning 11.00 am  |
| 4000     | Pi<br>Archaean | Precambrian   | Oldest known rocks on Earth.   | Beginning 3.00 am   |
| 4600     |                |               | Age of the Earth.  | Beginning 1 second<br>after midnight                      |

#### The Geological Timescale and County Tipperary



A simplified geology map of County Tipperary outlining the main geological units.

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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 Programme of Geological Survey Ireland 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 Geological Survey Ireland, over the course of numerous county audits since 2004.

# **County Geological Sites - a step by step guide**



# Appendix 2 - Bibliography – Geology of County Tipperary

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# Appendix 5 – 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 County Tipperary 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 the building of high mountain chains, ice sheets covering the land surface and so on. However, in County Tipperary there are relatively few sites representing the active geomorphological or land-forming processes of today.

#### Landslides and bog flows

Geological Survey Ireland has been compiling national data on landslides in the past decade. There were over forty events recorded in Tipperary, the majority in the Galtee Mountains and Knockmealdown Mountain areas. See <u>https://www.gsi.ie/en-ie/programmes-and-projects/geohazards/Pages/default.aspx</u>

#### 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, <u>www.floods.ie</u>, can be consulted for details of individual flood events in County Tipperary. Karstic flooding can occur when underground passages are unable to absorb high rainfall events. The Carboniferous limestone bedrock in County Tipperary is known to be heavily karstified in places, just like upland limestone areas such as the Burren or the Bricklieve Mountains. Significant karst sites occur at Mitchestown Caves and Roaring Wells, as well as the wider valleys in south County Tipperary.

#### Radon

Radioactive minerals and gases at higher concentrations can be carcinogenic. Radon can seep into homes and workplaces and can be carried in water supplies. A map showing the areas predicted to be at particular risk from radon in Ireland, called High Radon Areas, can be seen on the EPA website at <a href="http://www.epa.ie/radiation/#.VRu9OVROPcs">http://www.epa.ie/radiation/#.VRu9OVROPcs</a>. The Radiological Protection Institute of Ireland was formerly responsible for this but has been merged with the EPA.

#### **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. Tipperary is a county quite dependent on groundwater supplies, with much of it's drinking water being sourced in karstified limestone or sand and gravel aquifers, and therefore the risk is more serious than for most other counties. As the groundwater is often contained within limestone, it should be noted that karstic springs 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.

# Appendix 6 – Data sources on the geology of County Tipperary

This section is a brief summary of relevant Geological Survey Ireland datasets, to assist any enquiry concerning geology and to target possible information easily. Geological Survey Ireland has very many datasets, accumulated since it began mapping Ireland's geology in 1845. A Document Management System (called GOLDMINE) is freely available online, into which about half a million documents and maps have been scanned. This means that any user can search on screen for data of relevance to them. **Data are available free of charge**.

Key datasets include:

**GOLDMINE** (<u>Geological Survey Ireland OnLine Document</u>, <u>Maps and InformatioN Explorer</u>). The Geological Survey Ireland online digital archive enables visitors to search the Geological Survey of Ireland online data archive database and download full-size resampled pdfs and/or original high resolution TIFF image files. The data consists of: Scanned Capture of 450,000 pages and maps, including all of GEOLOGICAL SURVEY IRELAND principal datasets, (Mineral Exploration Reports-Open File, Geotechnical Reports, boreholes & tests, Historic 6":1 mile and 1":1 mile Geological Maps, GEOLOGICAL SURVEY IRELAND Publications, Bulletins, Published and Unpublished Reports, Groundwater Well Hydrographs, Marine Maps, Airborne Geophysical Maps, Mineral Locality Reports and Mine Record Reports and Maps). The database runs on Oracle© and the stored imagery is currently 1.4TB in size. <u>https://secure.dccae.gov.ie/goldmine/index.html</u>

## 1:100,000 Map Report Series

All historical, modern and other mapping has been compiled into very useful maps and reports that describe the geology of the entire country. Sheets 18 and 22 cover County Tipperary.

## 19<sup>th</sup> 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.

## 19<sup>th</sup> century one inch maps and Memoirs

Information from the detailed 19<sup>th</sup> century mapping was distilled into one inch to the mile maps, of which parts of parts of Sheets 116, 117, 125, 126, 134, 135, 136, 144, 145, 146, 154, 155, 156, 165, 166 and 167 cover County Tipperary. 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 scanned and uploaded on GOLDMINE.

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

## **Open File Data**

Each Mineral Prospecting Licence issued by the Exploration and Mining Division (EMD), currently of the Department of Communications, Climate Action and Environment, 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. Licences relate to numbered prospecting areas, and these are available on a map from EMD. See also <u>www.mineralsireland.ie</u>

### **MinLocs Data**

The MinLocs Database records all known mineral occurrences, however small, from GEOLOGICAL SURVEY IRELAND records, such as 19<sup>th</sup> century field sheets and Open File data.

### **Subsoils Mapping**

Since a Groundwater Protection Scheme has been completed by GEOLOGICAL SURVEY IRELAND (2012) for the whole country, a modern map of the subsoil types and depths across County Tipperary 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 published by GEOLOGICAL SURVEY IRELAND in late 2014, now provides more data. Specific groundwater group scheme supply sources such as Moyne and Mota Coolbaun have had more detailed studies completed for them.

Digital mapping of many different datasets is now available via an easy to use public viewer on the Geological Survey Ireland website: <u>www.gsi.ie</u>

### **Tellus Mapping**

Tellus is a regional mapping project, combining airborne geophysical and geochemical surveys to provide geoscientific information for the island of Ireland. Since 2004, almost 50,000 km<sup>2</sup> of the island of Ireland has been surveyed or partially surveyed through the Tellus surveys, which support mineral exploration, environmental management, agriculture and research activity. Geological Survey Ireland aims to complete both geochemical and geophysical Tellus surveying of the country by the end of 2028. Geophysical surveying has been completed over part of County Tipperary. Data is freely available at <a href="https://www.GeologicalSurveyIreland.ie/en-ie/programmes-and-projects/tellus/Pages/Data-and-Maps.aspx">https://www.GeologicalSurveyIreland.ie/en-ie/programmes-and-projects/tellus/Pages/Data-and-Maps.aspx</a>



### **Historic Mine Records**

Abandonment plans and varied other material exists for the numerous mining ventures in the county. The range of data varies from single items for some historical mine sites, to immensely detailed series of plans for more modern mine sites such as at Silvermines and Gortdrum. Virtually all of these are scanned and available on GOLDMINE (see above) but there is occasionally additional material in the paper records, such as photographs, that did not get scanned. Additionally, the scanned material did not include some very historic or rare plans and documents that were stored in a separate archive.

### Shortlist of Key Geological References

This reference list includes a few **key** papers, books and articles on the geology and geomorphology of County Tipperary that are recommended as access points to County Tipperary's 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 County Tipperary that could be traced. Many papers that refer to the Midlands area or South of Ireland areas in general, may or may not be specifically relevant to County Tipperary. Similarly there are many papers addressing the geology and wider development of the Slieve Ardagh Coalfield. Many of these may have no significant detail on the rocks of Tipperary itself.

### **Caves and Karst References**

The references in Appendix 3 all cover the karst and cave references for County Tipperary.

#### **Quaternary References**

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



A detailed geological map of County Tipperary.

### Appendix 7 – Further sources of information and contacts

Siobhan Power of the Geological Survey of Ireland can be contacted in relation to any aspect of this report. Roisin O'Grady, the Heritage Officer of Tipperary 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 Culture, Heritage and the Gaeltacht. The names and phone numbers of current staff may be found in the phone directory, or at <u>www.npws.ie</u>.

### Web sites of interest

<u>www.geologicalmaps.net/</u> - for historical geological maps <u>www.geology.ie</u> – the website of the Irish Geological Association who run fieldtrips and lectures for members, including many amateur enthusiasts <u>www.earthscienceireland.org</u> – a legacy website for a group which has ceased operation, for general geological information of wide interest and a series of magazines to download <u>http://www.iqua.ie</u> - for information, fieldtrips, lectures etc in relation to Ireland's Ice Age history <u>http://www.progeo.se/</u> - for information about ProGEO the European Association for the Conservation of Geological Heritage

## Appendix 8 – Geoschol leaflet on the geology of County Tipperary



AREA OF COUNTY: 4,303 square kilometres or 1,661 square miles

COUNTY TOWN: Nenagh (north) and Clonmel (south)

OTHER TOWNS: Cahir, Cashel, Roscrea, Thurles, Tipperary

**GEOLOGY HIGHLIGHTS:** Cooksonia an early land plant, Rock of Cashel, Slieveardagh Coalfield, Killaloe Slate, Slievenamon pebble beds.

AGE OF ROCKS: Silurian to Carboniferous; Paleogene



Slievenamon to Slieveardagh

Blocks of Devonian conglomerate are strewn across the summit of Slievenamon, towering above the lowlands formed on the younger Carboniferous limestones. In the distance are the low hills of Slieveardagh, formed of still younger Carboniferous sandstones and mudstones.

### COUNTY GEOLOGY OF IRELAND: Tipperary



Geological Map of County Tipperary

Green: Silurian; Beige: Devonian sandstones and conglomerates; Light blue: Lower Carboniferous limestone; Brown: Upper Carboniferous shales.

### **Geological history**

2

During the Silurian period (430 million years ago [Ma]) Ireland was divided into two by a narrowing ocean called Iapetus. Muds and some sand were deposited into this ocean and these later made up the mountainous areas of The Silvermines, Devilsbit Mountains to the north and Slievenamon to the southeast. Later compression caused some of these muds to be turned into slate. By the beginning of Devonian (416 Ma) the Iapetus ocean had closed completely and a large continent had formed, that was thinly vegetated, and through which temporary rivers flowed. Sandstones and coarse conglomerates were deposited, and these now form the lofty ridges of Slievenamon and the Galtee and Knockmealdown Mountains. Following the Devonian the landmass was slowly covered by a shallow ocean that encroached northwards over time. This was warm and supported a huge diversity of living things which are now found as fossils preserved in the Lower Carboniferous limestone.



### Cooksonia from near Moneygall (left), with a reconstruction.

Later in the Carboniferous the region became land. Sandstones and mudstones, with thin coal seams, were deposited and these now form the low hills of Slieveardagh.

The youngest bedrock deposits are found as scattered patches of clay



preserved in hollows in the underlying limestone of the Suir valley around Caher (not shown on map). Pollen grains have shown these so-called 'pipe clays' to be around 30 Ma -Paleogene (Dark green on timescale). Erosion has taken place during and since the Ice Age and some of the older rocks such as those of the Silurian have been revealed peaking out through younger rocks that once covered but now surround them.

### - 250- Cooksonia: an early land plant

In the early 1970s John Feehan, then a student at Trinity College, Dublin was examining mudstones and other rocks on a mountainside close to Moneygall. Once viewed under a microscope these rocks revealed a startling secret: they contained fossil plants. These were exceptional plants not much larger that 2-3 mm in height, and are called *Cooksonia*. They were among the first plants to have evolved that could live on land some 440 Ma. Unlike algae that had to live in water *Cooksonia* had short stems with tubes that could carry water to the tips of stems. On the tips the mature plants had small swellings that held spores which when released would germinate into new plants.

THE FARTH 4,500- Geological timescale showing age of rocks in Tipperary.

### Economic minerals and resources: coal, slate and metals

Coal was mined from the Slieveardagh Coalfield in the east of the county from at least 19 collieries. The last finally closed in 1973. Like all coal in Ireland it is Upper Carboniferous in age and formed from forests that grew in swamps close to sea level. These developed as the warm, tropical seas that had covered Ireland in the Lower Carboniferous retreated. The plants flourished, and as they died they fell over and began to build-up. Over time they became compressed into coal. Some of the coal seams that were mined were up to 120 cm in thickness.

Slate is a metamorphic rock that was originally a mudstone that became compressed over time. This allowed the slates to be spilt into very thin slices ideal for roofing. At Portroe near Killaloe good quality slate was discovered and this supported an extractive industry where various quarries were worked from the 1820s until their closure in the 1950s. For a short time in the 1990s a slate quarry was reopened at Killoran.

Historic mines operated in the Silvermines (pictured right) near Nenagh at many times in the past up until the 1990s. Silver was the main metal extracted in historictimes and Lead and Zinc in more modern times. Today a large wedge-shaped spoil heap of waste

4



from the mines can be seen on the side of the Silvermines Mountain. In the 1980s a considerable time was spent prospecting for viable metal sources in the Lower Carboniferous limestones of the Irish midlands. Close to the Kilkenny border at Lisheen a deposit was discovered that contained a large proportion of lead and zinc ores and these are now being mined.

Map adapted with permission from Geological Survey of Ireland 1:1,000,000 map 2003. Image credits: Mike Simms 1, 4; Geological Museum, Trinity College, Dublin 3. Text by Patrick Wyse Jackson & Mike Simms

# Appendix 9 – Glossary of geological terms

| Adit                           | a horizontal or only gently inclined mine tunnel dug to access ore, or to drain, ventilate or further develop a mine |
|--------------------------------|--|
| Alluvial Deposit /<br>Alluvium | unconsolidated clay, silt, sand and gravel, deposited by a body of running water.                                    |
| Anthracite                     | a coal of high rank, that is high in carbon and low in gas and volatile  |
| Anticline                      | a structural geological term meaning an upfold of sedimentary strata in a linear                                     |
| Aquifer                        | a permeable water saturated rock unit  |
| Artesian Well                  | a well from which water flows under natural pressure without numping   |
| Backwall                       | the cliffs at the rear section of a corrie   |
| Bucktun                        | low areas in the Earth's crust of tectonic origin in which sediments have  |
| Basin                          | accumulated.   |
| Bead (of an esker)             | a segment of an esker  |
| Bedding plane                  | the contact between individual beds of rock  |
|                                | a general term for the rock, usually solid, that underlies soil or other   |
| Bedrock                        | unconsolidated, superficial material.  |
| Bioclast                       | fragment of a shell or fossil forming part of a sedimentary rock.  |
| Biostratigraphy                | using fossils to define the succession of rocks  |
|                                | unconsolidated, unsorted glacial deposits consisting of boulders and cobbles   |
| Boulder Clay                   | mixed with very finely ground-up rock or silt. Also known as till.   |
|                                | a marine invertebrate of the phylum Brachiopoda - a type of shellfish. Ranging                                       |
| Brachiopod                     | from Lower Cambrian to present.  |
|                                | invertebrates belonging to the phylum Bryozoa, ranging from Ordovician to  |
| Bryozoa                        | present, often found as frond-like fossils.  |
| Calcareous                     | containing significant calcium carbonate.  |
|                                | a pale mineral composed of calcium carbonate, which reacts with dilute   |
| Calcite                        | hydrochloric acid.   |
| Calp                           | dark grey, fine-grained, muddy limestone.  |
| Carbonate                      | a rock (or mineral), most commonly limestone (calcite) and dolomite.   |
|                                | 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                                    |
| Cave                           | the coastline, where the sea erodes natural rock fractures.  |
|                                | a landform consisting of the outline of a path of relatively shallow and narrow                                      |
| Channel                        | body of fluid, most commonly the confine of a river, river delta or strait.  |
| Chert                          | a sedimentary rock comprising of very fine-grained quartz.   |
|                                | an individual constituent, grain or fragment of a sediment or rock, usually  |
| Clast                          | produced by mechanical weathering (disintegration) of a larger rock mass   |
| Conglomerate                   | sedimentary rock comprising of large rounded fragments in a finer matrix   |
| Carl Cara                      | a coal seam is a strata or bed of coal, outcropping over a wide area, but not  |
| Coal Seam                      | necessarily very thick.  |
| Corrie                         | a norsesnoe-snaped, steep-walled valley formed by glacial erosion.   |
|                                | a steep resistant rock mass (crag), with stoping softer sediments (tail) protected                                   |
| Crag and tail                  | rido   |
|                                | suce.  |
| Crinoid                        | floor and a body cup with arms which may be branching (a sea lify)   |
| Crinolu                        | lavering in sedimentary rocks at an inclined angle to bedding formed by current.                                     |
| Cross-bedding                  | rinnles  |
|                                | a low nearly flat alluvial tract of land at or near the mouth of a river commonly                                    |
|                                | forming a fan or triangular shaped plain of considerable area, which is crossed by                                   |
|                                | many smaller channels of the main river. Glacial deltas are formed by meltwater                                      |
| Delta                          | in a similar fashion, at the edge of glacial lakes.  |

| Diamictite     | the area between the surface and the water table.                                   |
|----------------|---|
| Diatom         | a major group of algae, among the most common types of phytoplankton.               |
|                | 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       |
| Dip/dipping    | the strata or beds.   |
| Doline         | circular/oval closed depression found in karst terrain.                             |
|                | calcium- and magnesium-bearing carbonate mineral; also a rock composed of           |
| Dolomite       | the mineral.  |
|                | a streamlined mound of glacial drift, rounded or elongated in the direction of the  |
| Drumlin        | original flow of ice.   |
|                | a sub-vertical sheet-like igneous intrusion, typically in-filling a fracture in the |
| Dyke           | earth's crust.  |
|                | a large rock fragment 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.      |
| Erratic        | Tracing their source can yield important information about                          |
|                | an elongated ridge of stratified sand and gravel which was deposited in a           |
|                | subglacial channel by meltwaters. Eskers are frequently several kilometres in       |
| Esker          | length.   |
|                | the character of the rock derived from its original sedimentary environment and     |
| Facies         | process of deposition.  |
|                | a usually triangular deposit of sand and gravel deposited by a glacial stream,      |
| Fan            | either under a lake or under air.   |
|                | planar fracture in rocks across which there has been some displacement or           |
| Fault          | movement.   |
| Fauna          | collective term used to group all animal life.                                      |
|                | a flat or nearly flat land area adjacent to a stream or river that experiences      |
| Floodplain     | occasional or periodic flooding.  |
| Fluvial        | pertaining to a river or stream.  |
| Fold(ing)      | flexure in layered rocks caused by compression.                                     |
|                | a formal term for a sequence of related rock types differing significantly from     |
| Formation      | adjacent sequences.   |
|                | any remains, trace or imprint of a plant or animal that has been preserved in the   |
| Fossil         | Earth's crust since some past geological or prehistorical time.                     |
| Glacial        | of or relating to the presence and activities of ice or glaciers.                   |
|                | pertaining to the meltwater streams flowing from wasting glacier ice and            |
| Glaciofluvial  | especially to the deposits and landforms produced by such streams.                  |
|                | a sorting effect with the coarsest material at the base of the bed and finest       |
| Grading        | grained material at the top.  |
|                | an impure sandstone, characterised by poorly-sorted, angular grains in a muddy      |
| Greywacke      | matrix, that was deposited rapidly by turbidity currents (submarine avalanches).    |
|                | residual, isolated hill formed through karst processes, sometimes stubby and        |
| Hum            | smoothed out by later erosional processes, e.g. glaciation.                         |
|                | a small hill or knoll in the landscape, which may be formed by many different       |
| Hummock        | processes.  |
| Ice margin     | the edge of an ice sheet or glacier.  |
| Inlier         | area of older bedrock completely surrounded by younger bedrock.                     |
| Interglacial   | the time interval between glacial stages, or pertaining to this time.               |
|                | 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       |
| Irish Sea Till | Sea Basin during the last glaciation  |
| Joint          | a fracture in a rock, which shows no evidence of displacement.                      |
|                | general term used for landscapes formed by weathering of soluble rocks, usually     |
| Karst          | limestone, by surface water and/or groundwater.                                     |
| Laminated      | the finest example of stratification or bedding, typically exhibited by shales and  |

|                   | fine-grained sandstones.  |
|-------------------|---|
| Lava              | magma extruded onto the Earth's surface, or the rock solidified from it.            |
|                   | a sedimentary rock consisting chiefly of calcium carbonate (CaCO3), primarily in    |
| Limestone         | the form of the mineral calcite.  |
|                   | the description of rocks on the basis of such characteristics as colour,            |
| Lithology         | composition and grain size.   |
|                   | 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          |
| Lodgement         | emplaced by this process (i.e. lodgement till).                                     |
|                   | a bend in a sinuous watercourse or river which forms when moving water in a         |
|                   | stream erodes the outer banks and widens its valley, and the inner part of the      |
| Meander           | river has less energy and deposits fine sediment.                                   |
| Meltwater         | water from melted snow or ice.  |
|                   | a channel cut by glacial meltwater, either under, along or in front of an ice       |
| Meltwater channel | margin.   |
|                   | referring to the process of metamorphism or to the resulting metamorphic rock,      |
|                   | transformed by heat and pressure from an originally igneous or sedimentary          |
| Metamorphic       | rock.   |
| Metasediments     | metamorphosed sediments.  |
|                   | any glacially formed accumulation of unconsolidated debris, in glaciated regions,   |
| Moraine           | such as during an ice age.  |
|                   | an exposed, often rocky element of a ridge, mountain, or peak not covered with      |
| Nunatak           | ice or snow poking up above an ice sheet or glacier.                                |
| 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. |
| Outlier           | area of younger bedrock completely surrounded by older bedrock                      |
| Periglacial       | very cold but non-glacial climatic conditions                                       |
|                   | 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     |
| Plate tectonics   | at their boundaries with one another.   |
|                   | the area below the water table, where the rock is completely saturated with         |
| Phreatic Zone     | water.  |
|                   | an area of acid, peaty soil, in which the centre is relatively higher than the      |
| Raised Bogs       | margins   |
|                   | 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             |
| Sandstone         | minerals.   |
|                   | a plain formed of glacial sediments deposited by meltwater outwash at the           |
| Sandur            | terminus of a glacier   |
|                   | a rock formed by the deposition of sediment, or pertaining to the process of        |
| Sedimentary       | sedimentation.  |
|                   | a vertical or inclined hole dug in a mine for access, ventilation, for hauling ore  |
| Shaft             | out or for pumping water out.   |
|                   | A fine-grained sedimentary rock, formed by the compaction and lithification of      |
| Chala             | ciay, slit, or mud. It has a finely laminated (composed of layers) structure that   |
| Shale             | gives it a fissility, or tendency to split along bedding planes.                    |
| Ciltatore         | is similar to mudstone but with a predominance of silt sized (slightly coarser)     |
| Sitstone          | particles.  |
| Clata             | is a line-grained metamorphic rock produced from a sedimentary mudstone by          |
| Sidle             | pressure, imposing a cleavage along which the state easily splits.                  |
| Stratiform        | the point where an underground stream reaches the surface.                          |
| Stratiform        | occurring as a bed or beds, arranged in strata                                      |
| Chunchingung have | the study of stratified (layered) sedimentary and volcanic rocks, especially their  |
| Stratigraphy      | sequence in time and correlation between localities.                                |

| Syncline     | a structural geological term meaning a downfold of sedimentary strata in a linear trough shape.   |
|--------------|---|
|              | terraces are remnants of the former floodplain of a stream of river, formed by  |
|              | the downcutting of a river or stream channel into and the abandonment and   |
| Terrace      | lateral erosion of its former floodplain.   |
| Terrigenous  | something derived from the land or continent.   |
|              | unconsolidated, unsorted glacial deposits consisting of boulders and cobbles<br>mixed with very finely ground-up rock as sand, silt or clay also known as boulder |
| Till         | clay.   |
|              | rock formed from pyroclastic volcanic ash material usually composed of silt-sized   |
| Tuff         | to sand-sized particles.  |
|              | a buried erosion surface separating two rock masses or strata of different ages,  |
| Unconformity | 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.   |
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# 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 Tipperary. 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 Programme 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 several low resolution photographs exemplifying the site. **Further pictures of most sites at higher resolution, should they be required for a glossy booklet or leaflet for the general public are provided to the Heritage Officer and held in Geological Survey Ireland**. Grid references are given for a central point in the site generated from the GIS mapping (a shapefile) of the site boundary. They are only indicative of the location, but the site extent is best shown on the included maps.

### **Coordinate Projection System – IRENET95 ITM**

Irish Transverse Mercator (ITM) is the geographic projection co-ordinate system now in use for Ireland, and has been applied to all site localities in the site reports. It is the standard co-ordinate system for OSi maps, including the new Discovery map series, but a coordinate conversion tool is available on the OSi website at: <u>https://gnss.osi.ie/new-converter/</u>

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 audit contract. Boundaries are drawn to include the geological or geomorphological interest of the site, but are often 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 fully 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 if and when 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 Geological Survey Ireland 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 Siobhan Power, Geoheritage Programme, Geological Survey Ireland, Beggars Bush, Haddington Road, Dublin D04 K7X4. Phone 01-6782760. Email: Siobhan.power@gsi.ie



Simplified Geological Map of County Tipperary with site locations indicated.